BBC THE SCIENCE BEHIND SEPTEMBER'S BEST STARGAZING

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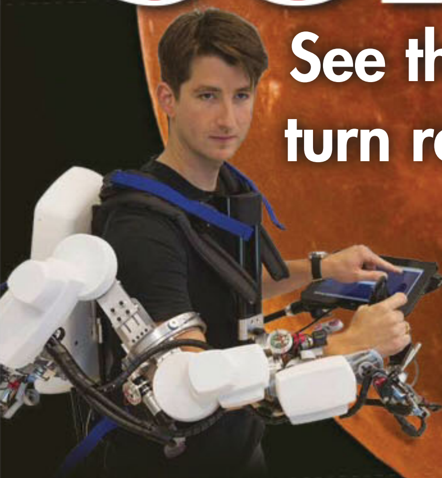
Sky at Night

ECLIPSE OF THE SUPERMOON

See the biggest full Moon of the year turn red in Earth's shadow this month

FULL OBSERVING & IMAGING GUIDE INSIDE



SPACE ROBOTICS

ESA tests the tech to control planetary rovers from orbit

LUNAR MASTERPIECE

Sketch a lasting record of your observations

UNEQUAL EQUINOX

Why day and night are not the same length

ALSO THIS ISSUE

1ST FOR GEAR

On test: The latest lightweight tracking mount for astro imagers

MYTH BUSTING

The truth behind astronomy's most pernicious falsehoods

ALIEN AURORAE

Discover the dancing lights of the Solar System's distant worlds

SEPTEMBER 2015 #124
www.skyatnightmagazine.com

Welcome

Get set for a marvellous eclipse of a 'supermoon'

Those of you who had your appetites whetted by the solar eclipse back in March will doubtless have ringed Monday 28 September in the calendar. This is the date of a rather special total lunar eclipse that coincides with a Harvest moon and a perigee Moon – or a 'supermoon' as it is popularly known. Our observing guide on page 50 and imaging guide on page 63 will leave you perfectly prepared for this event, when the Moon is likely to take on a dramatic red colour as the Sun, Earth and Moon move into syzygy.

Syzygy, the term for three bodies being aligned with one between the other, is just one example of astronomy's esoteric nature. It's not surprising that there are many more myths and misunderstandings, and on page 32 Mark Garlick puts some of the most commonly held ones to rights.

Also this issue, we look at new technology that you could be forgiven for thinking was pure science fiction, were it not for the fact that it is due to launch for the ISS. Turn to page 72 for the fascinating story of ESA's Interact experiment, the first step towards controlling robotic rovers on the surfaces of planets from space stations in orbit around them.

Enjoy the issue!

Chris Bramley Editor

PS Next issue goes on sale 18 October.

This month's contributors include...

WILL GATER
ASTRONOMY EXPERT

As well as the Moon, Cygnus is spectacular this month. Will guides us through the science of this stand-out constellation. *Page 38*

DEIRDRE KELLEGHAN
ASTRONOMY ARTIST

Sketching our nearest neighbour need not be a daunting task – as Deirdre explains, you don't even need to start big. *Page 44*

OLIVIA JOHNSON
SCIENCE EDUCATOR

One myth that emerges in September is that day and night are equal at the equinox. Olivia tells us why we're all wrong. *Page 78*

PETE LAWRENCE
IMAGING EXPERT

Pete gives us all the tools to image the lunar eclipse this month: timings, kit advice and more. *Page 63*

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Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...

TELEVISION
Find out what *The Sky at Night* team will be exploring in this month's episode on page 19

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In the magazine

NEW TO ASTRONOMY?
See *The Guide* on page 78 and our online glossary at www.skyatnightmagazine.com/dictionary

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REGULARS

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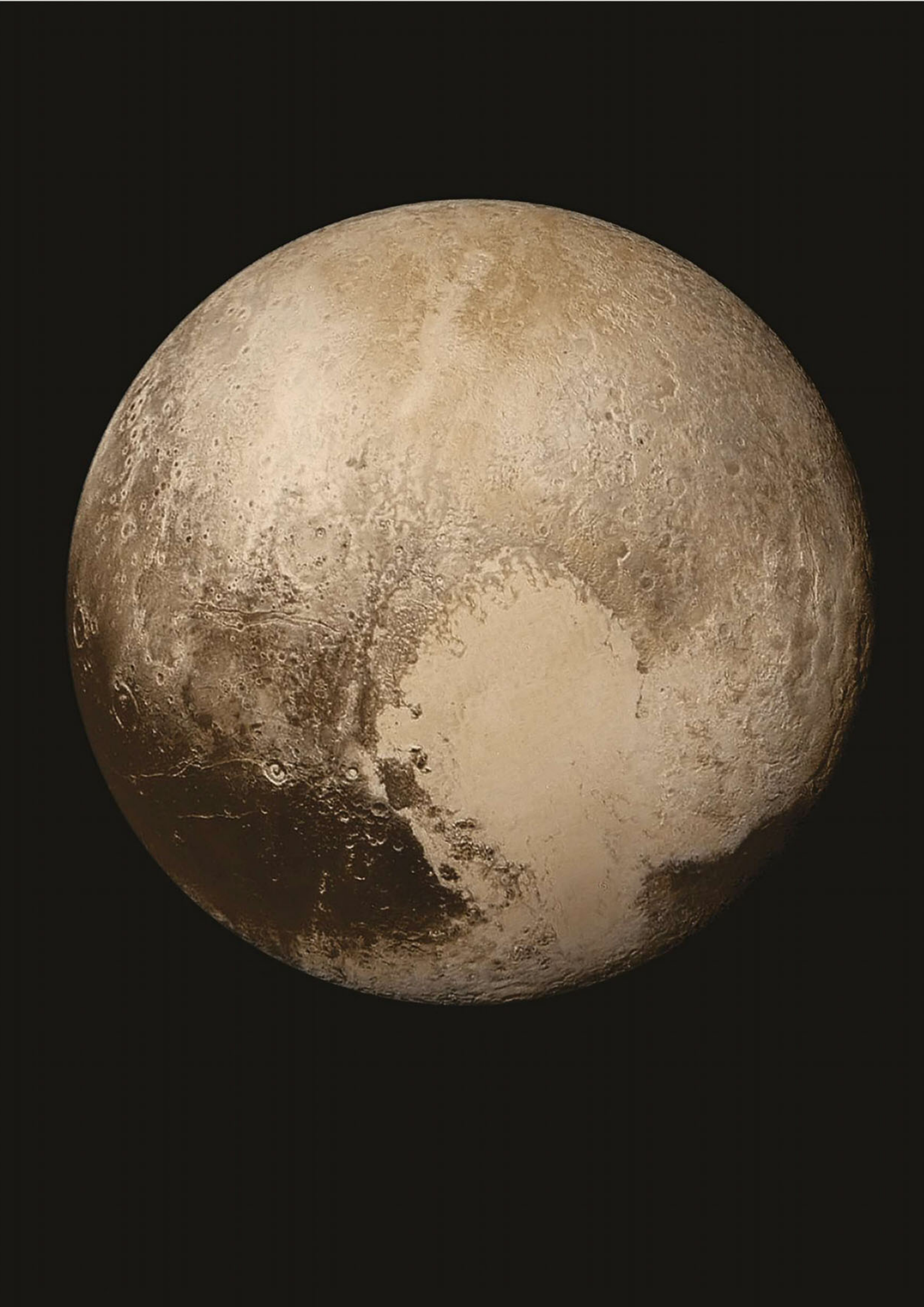


Mission accomplished

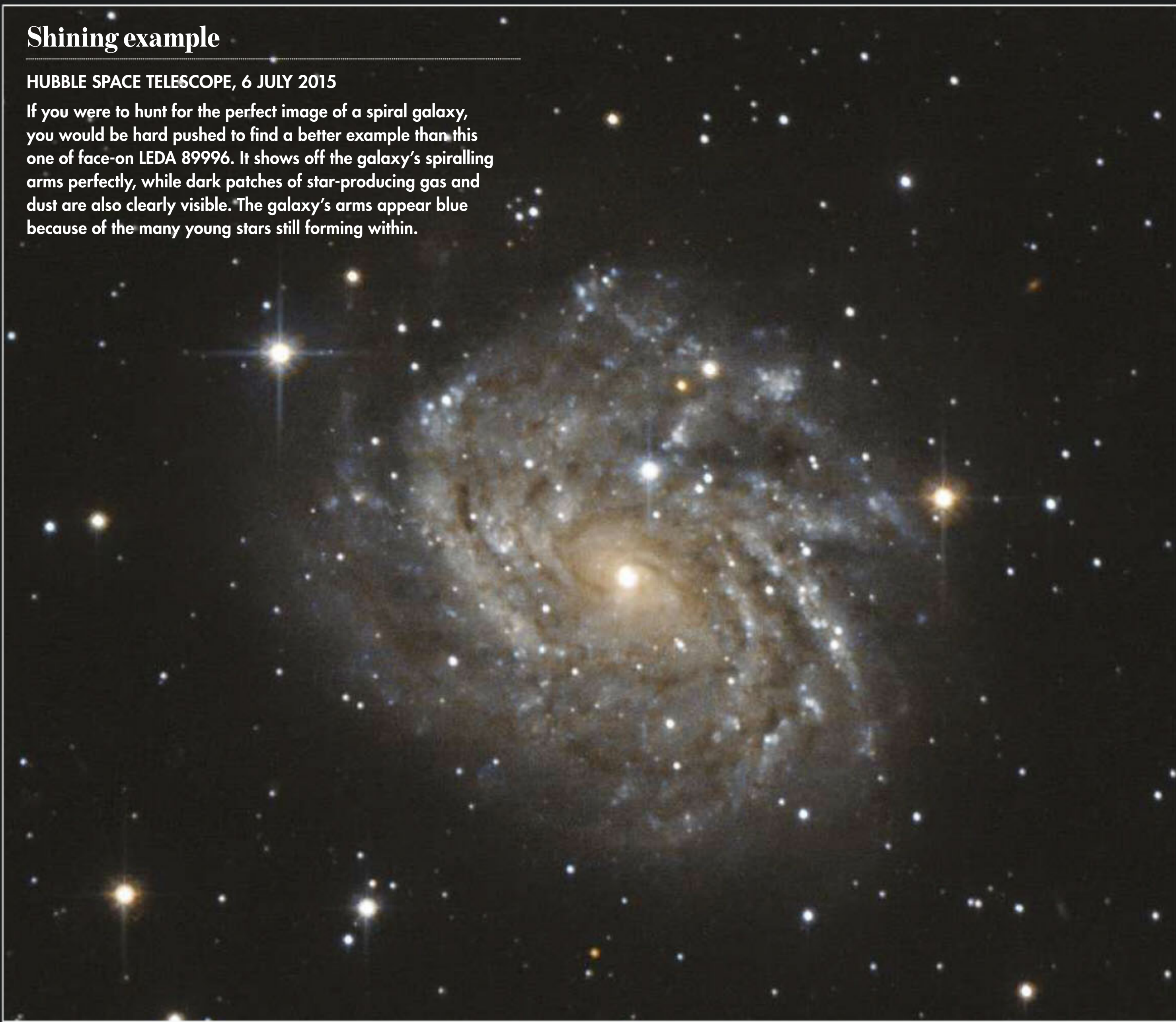
NEW HORIZONS SPACECRAFT, 24 JULY 2015

After a decade-long voyage across the Solar System, New Horizons finally sent back images of Pluto and its largest moon Charon. The highlight so far is undoubtedly this composite of four images captured during the approach

This pin-sharp view of Pluto is a composite of four images taken by New Horizons' LORRI camera and combined with colour data from the Ralph instrument. They were captured from a distance of 450,000km at such high resolution that features as small as 2.2km across are easily visible. The now famous heart-shaped Tombaugh Regio (named after Pluto's discoverer Clyde Tombaugh) is revealed in intricate detail, highlighting the distinctive and contrasting textures on Pluto's surface.

On the lower right, the image of Charon shows a 1,000km stretch of cliffs and troughs along the moon's surface, which may be a result of fracturing caused by internal geological processes. New Horizons mission scientists have made particular note of Charon's smooth surface – there do not appear to be as many craters as we might expect. This, it has been suggested, indicates the moon's surface is relatively young, perhaps also having been reshaped in the recent past. However, the compression of the image could mean some areas are rougher than they appear. The uncompressed version is due to be sent back to Earth at a later date.

New Horizons travelled about 5 billion km over 9.5 years to reach the Pluto system. Following the culmination of the flyby, the spacecraft is continuing its journey into the Kuiper Belt at the outer edge of the Solar System. As the probe ventures deeper into space, the data it sends back to Earth will help us understand more of the secrets behind our Solar System and its evolutionary history.



Shining example

HUBBLE SPACE TELESCOPE, 6 JULY 2015

If you were to hunt for the perfect image of a spiral galaxy, you would be hard pushed to find a better example than this one of face-on LEDA 89996. It shows off the galaxy's spiralling arms perfectly, while dark patches of star-producing gas and dust are also clearly visible. The galaxy's arms appear blue because of the many young stars still forming within.

Observational overview ▶

EUROPEAN SOUTHERN OBSERVATORY, 30 JUNE 2015

The European Southern Observatory in Chile is supported by the UK, Germany, France, Spain and Switzerland, among others, and provides research facilities to astronomers from across the world. Here, a composite image shows all of ESO's observatories and its headquarters, set against the backdrop of the arcing Milky Way.

▲ Colourful star cluster NGC 2367

MPG/ESO 2.2M TELESCOPE, 1 JULY 2015

Captured by the Wide Field Imager on MPG/ESO's 2.2m telescope, this view of young cluster NGC 2367 shows active area of gas and bright stars. NGC 2367 is still in its infancy, but lies within a bigger and much older structure on the edges of the Milky Way.

▼ Cosmic fireworks

CHANDRA X-RAY OBSERVATORY/SPITZER SPACE TELESCOPE, 16 APRIL 2015

This composite image of NGC 1333 shows X-rays in pink and infrared data in red. This open cluster subject is 780 lightyears away and crowded with very young stars – some of which are less than two million years old. The Chandra data reveals 95 young stars, 41 of which had not previously been identified by Spitzer because they were not emitting infrared light.

Stellar light echoes ▶

CHANDRA X-RAY OBSERVATORY, 23 JUNE 2015

The rings seen in this image from the Chandra X-ray Observatory are light echoes, caused by X-rays from star system Circinus X-1 bouncing off clouds of dust. These are the largest and brightest rings from X-ray light echoes ever observed, and they were caused by a flare from a neutron star within the system. The echoes have given astronomers a rare chance to accurately pinpoint the star's distance from Earth: it is about 30,700 lightyears away.

X-RAY: NASA/CXC/UNIV. OF WISCONSIN-MADISON/S.HEINZ ET AL; OPTICAL: DSS, NASA/CXC/SAO/S.WOLK ET AL; OPTICAL: DSS & NOAO/AURA/NSF; INFRARED: NASA/JPL-CALTECH, ESA/HUBBLE & NASA, ESO/G. BECCARI

Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS CUTTING EDGE

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Our experts examine the hottest new astronomy research papers

New Horizons reaches Pluto

The surface of the distant world is much younger than anyone expected

THE FIRST CLOSE-UP images of Pluto and its moon Charon have been sent back to Earth by the New Horizons spacecraft following its historic flyby. The probe passed the dwarf planet at 11:49:57 UT on 14 July and began transmitting data back a few days later. Though only a handful of images have made it back to Earth so far, they have already thrown up a couple of surprises.

Several large areas of both Pluto and Charon are free of impact craters, suggesting that some mechanism is renewing the surface. A heart-shaped feature, informally named the Tombaugh Regio after the planet's discoverer, covers a large portion of the planet's southern hemisphere, the surface of which only appears to be around 100 million years old.

▲ Backlit by the Sun, Pluto's atmospheric haze rings the planet

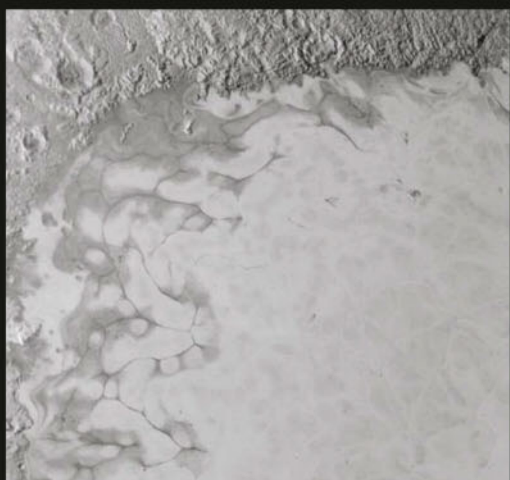
"This terrain is not easy to explain," says Jeff Moore of New Horizons' geology, geophysics and imaging team. "The discovery of vast, craterless, very young plains on Pluto exceeds all pre-flyby expectations."

The early images have also revealed mountains far larger than researchers can easily explain and an icy haze around the planet. It is hoped that the full dataset from the flyby, which will be downloaded over the next 16 months, will supply some answers.

"After nearly 15 years of planning, building, and flying the New Horizons spacecraft across the Solar System, we've reached our goal," says the mission's project manager Glen Fountain. "The bounty of what we've collected is about to unfold."

► **See Comment, right**

▲ Two icy mountain ranges have been found so far; this is the second, on the edge of the Tombaugh Regio



▲ Part of the light, heart-shaped Tombaugh Regio up close; it is much smoother than anticipated

NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE X 3

COMMENT

by Chris Lintott

Wasn't that fun? I can think of few space events I've enjoyed more than New Horizons' brief encounter with Pluto. The pace of a flyby made for an exciting scientific ride as theories were invented, argued about and discarded as soon as the next picture came down.

One debate we could have done without is that over Pluto's planethood, the least interesting thing about this fascinating world. What was sad was the realisation that we've somehow given the impression that Pluto was demoted because it was boring, but nothing could be further from the truth.

Whatever we call it, this fascinating place makes me anxious for worlds yet unseen. It would be wonderful to go back to Triton, or to Uranus's moons, which we now know less well than Pluto. Who knows what Eris or Makemake look like? Who knows what Pluto will look like when we eventually return? As ever, a successful mission makes me hungry for more.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF

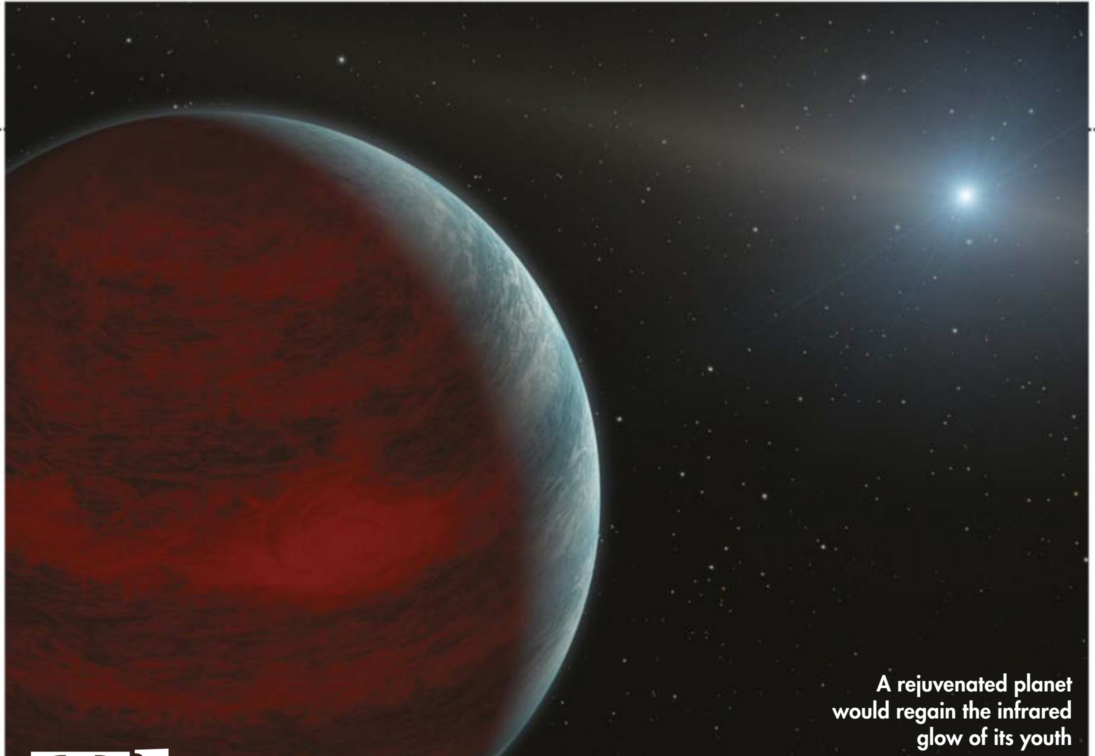
PULSAR SET FOR FIREWORKS

Astronomers are preparing for high-energy fireworks in 2018 as a pulsar heads for one of the brightest stars in our Galaxy – its own companion. The star is surrounded by a large debris disc, which the pulsar passes through every 25 years, and should be quite a show. "This forewarning of the energetic fireworks expected at closest approach in three years' time allows us to prepare to study the system across the entire electromagnetic spectrum with the largest telescopes," says Ben Stappers of the University of Manchester.

BOOST TO UK SPACE INDUSTRY

Two new facilities have opened at the UK Space Gateway in Oxfordshire, including ESA's first British office. The development hopes to grow the UK space industry by creating ground-based infrastructure and a centre for technological development. "Our investment in collaborative space science means the UK has the know-how and technical expertise to provide exciting and innovative space solutions," says Jo Johnson, Minster for Universities and Science.

NASA'S GODDARD SPACE FLIGHT CENTER, ESA/A. LE FLOC'H, NASA/JPL-CALTECH, SETI INSTITUTE/DANIELLE FUTSELAAR, M. HELFENBEIN, YALE UNIVERSITY/OPAC, NASA/ESA, ESA/ROSETTA/NAVCAM – CC BY-SA IGO 3.0



A rejuvenated planet would regain the infrared glow of its youth

The cosmic fountain of youth

Dead stars may be able to reinvigorate planets around them

DEAD STARS MAY be able to give planets back their youthful infrared glow, according to new evidence found by researchers.

"When planets are young, they still glow with infrared light from their formation," says Michael Jura of the University of California, Los Angeles (UCLA). "But as they get older and cooler, you can't see them anymore."

Towards the end of their lives stars like our Sun puff up their outer layers, expanding hugely. The loose gas is then blown away and some of this accumulates on the surface of the planets in the outer reaches of the planetary system. As the material falls onto it, the planet swells in mass, and friction causes it to heat up and glow.

Though this effect has been hypothesised for many years it wasn't until now that a candidate rejuvenated planet has been found.

The discovery stems from data collected by NASA's Wide-field Infrared Survey Explorer in 2006, in which an undergraduate student found an excess of infrared light around a white dwarf star, called PG 0010+280. At first the team thought the light was coming from a disc of material around the white dwarf. These discs are created when asteroids stray too close to the star and are broken apart. However, observations of this star didn't fit with this idea.

They then came to the notion that the infrared signature could come from a rejuvenated planet. The exact nature of the glow will most likely remain a mystery until 2018, when the James Webb Space Telescope begins operations. The scope should be able to differentiate between the glow of a dust disc and that from an alien world.

"I find the most exciting part of this research is that this infrared excess could potentially come from a giant planet, though we need more work to prove it," said Siyi Xu of UCLA and the European Southern Observatory. "If confirmed, it would directly tell us that some planets can survive the red giant stage of stars and be present around white dwarfs." www.jpl.nasa.gov/wise

Scientists say that Kepler 452b has a better than 50:50 chance of having an atmosphere and liquid water

The most Earth-like planet ever found

The super-Earth is in the right place for liquid water and could be rocky

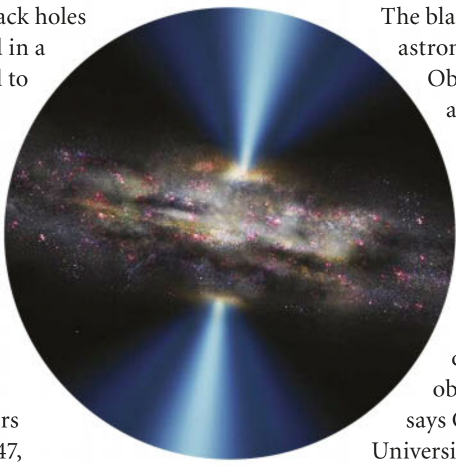
A PLANET HAILED as perhaps being the most Earth-like yet has been found in the habitable zone of a Sun-like star. Designated Kepler 452b, this planet is 60 per cent larger than our own, has an orbit of 385 days and is just five per cent farther from its star than Earth is from the Sun. As its star is 1.5 billion years older than our own, NASA scientists have described the planet as Earth's older and bigger cousin.

"Kepler 452b takes us one step closer to understanding how many habitable planets are out there," says Joseph Twicken, lead scientific programmer for the Kepler mission. "Continued investigation of the other candidates in this catalog ... will help us find the smallest and coolest planets. Doing so will allow us to better gauge the prevalence of habitable worlds."
www.seti.org

BLACK HOLE OUTGROWS HOME GALAXY

ONE OF THE most massive black holes ever discovered has been found in a galaxy that should be too small to house it. The galaxy, called CID-947, is over seven billion times the mass of the Sun and makes up 10 per cent of the mass of its host galaxy.

While most galaxies are thought to house black holes at their centres, most are only 0.2 to 0.5 per cent the mass of their galaxy, making this one abnormally large. However, stars are still forming within CID-947, so it could be that it is a precursor to one of the massive galaxies we now see in the current Universe.



▲ The black hole in galaxy CID-947 is considered much larger than it should be given the size of its host

The black hole was spotted by astronomers using the Keck Observatory in Hawaii during a survey charting the change in black holes over cosmic time. The galaxy is over 11 billion lightyears away and dates from when the Universe was two billion years old.

"Our survey was designed to observe the average objects, not the exotic ones," says C Megan Urry of Yale University. "It was quite a shock to see such a ginormous black hole in such a deep field."
www.keckobservatory.org

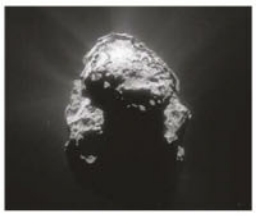
NEWS IN BRIEF

VISCOUS UNIVERSE COULD BE HEADING FOR A BIG RIP

A new mathematical technique has allowed scientists to create models of the Universe that include viscosity – the resistance to expansion and contraction. The added effect replicates some, but not all, of the expansion of the Universe that has been attributed to dark energy. The new results also indicate that the expansion will continue to the point where the Universe tears itself apart, a scenario called 'The Big Rip'.

COMET 67P NEARS PERIHELION

Comet 67P/Churyumov-Gerasimenko will pass 186 million km from the Sun on 16 August 2015, its point of closest approach. The Rosetta spacecraft has been orbiting the comet for over a year, and will have an unprecedented view as 67P goes through perihelion and becomes increasingly active as it heats up. The probe is currently orbiting at a distance of 150km as the comet's coma pushes on its huge solar panels, making it hard to maintain a closer orbit.

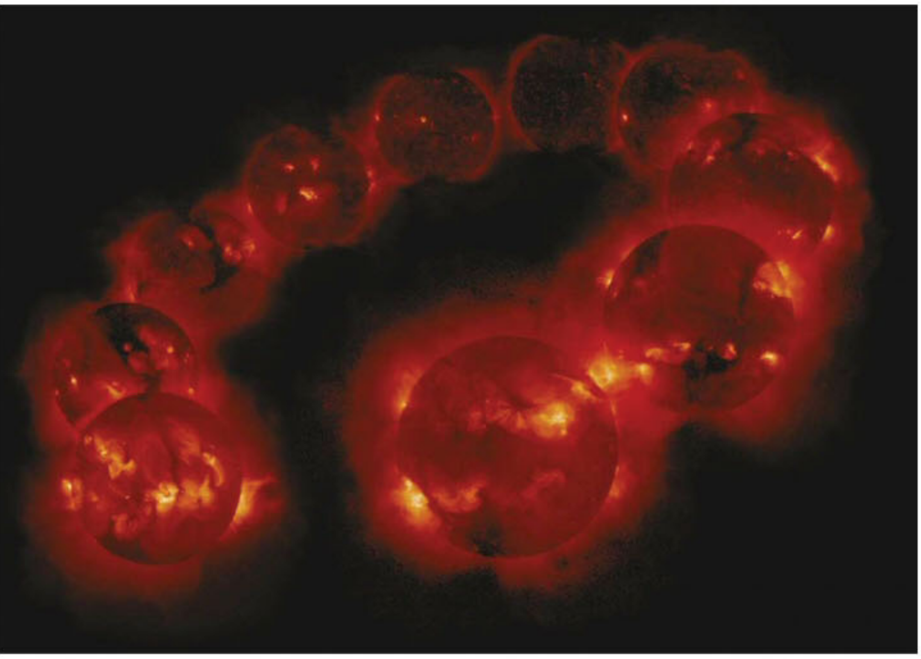


CUTTING EDGE

Our experts examine the hottest new research

Behind the weak solar cycle

The recent solar maximum was rather disappointing – perhaps sunspot tilts could help us understand why



YOHKOH/ISAS/LOCKHEED-MARTIN/NAOJ/U. TOKYO/NASA

▲ If this paper is right, and solar activity is linked to sunspot placement, then the accuracy of long-term forecasting is in doubt

It's been a frustrating and confusing few years for solar observers. The expected peak of sunspot activity, which comes roughly every 11 years, was difficult to discern. Activity rose, but never really became spectacular. We are past the peak now, but even looking back at the data it's hard to work out where the maximum really came. This cycle – the 24th since records began – was a damp squib, but the disappointing show is placed into even starker relief against the powerful peaks in activity seen during the second half of the 20th Century.

The sunspot cycle, like most of the changing phenomena on the Sun, is due to the influence of its powerful magnetic field. Caught up in our star's broiling, rotating atmosphere, the magnetic field twists and buckles. As the plasma that makes up the Sun flows in response to these magnetic motions, it creates the cooler regions we see as sunspots, dark against the bright background of the undisturbed solar surface.

This description of what's going on is well established, and few would argue with it. In this month's paper, three astronomers – two from Germany and one from China – take a closer look at what's going on in an attempt to understand why cycle 24 was so disappointing, and their first answer involves the past. This most recent cycle, it seems, was disappointing because the previous cycle wasn't great either; any observer will tell you that activity on the Sun's surface has been low for a long time, stretching back into the last decade, and the magnetic field has been weak for much of that time too.

That's critical because activity is created when magnetic fields get twisted by the Sun's rotation. Weaker fields means weaker activity, but the question then is what causes the weak magnetic fields in the first place. The authors look at what's known as the tilt angles of the sunspot groups, which is the angle between the poles of a sunspot and a line running east to west. This angle changes with latitude, a phenomenon known as Joy's Law after American astronomer Alfred Joy, who noticed that sunspot groups farther from the equator were more likely to have the leading spot closer to the equator than those following. This is an indication that the effect traces the changes in the magnetic field that also control activity.

Previous studies had looked at this effect in a statistical fashion, but with little luck. This paper found that the cycle was affected by a few large groups that appeared near the equator that were the 'wrong' way round – they didn't follow Joy's Law – and which seemed to have suppressed changes in the magnetic field.

> "This cycle, it seems, was disappointing because the one before it wasn't great either"

The details, as with anything involving magnetic fields, are complicated, but it has important conclusions for observers. If the strength of a cycle depends on whether large sunspot groups appear near the equator, and on which way round they are, then that makes long-term forecasting impossible. Until the solar minimum arrives, we have no way of saying anything about the next cycle. Depressing for physicists, perhaps, but observers at least can still hope for a dramatic recovery and some decent activity next time around.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading… *The cause of weak solar cycle 24* by Jie Jiang, Robert H Cameron and Manfred Schuessler
Read it online at http://arxiv.org/abs/1507.01764

NEWS IN BRIEF

FIRST COMMERCIAL SPACEFLIGHT CREW SELECTED

Four astronauts have been selected to train for the first commercial manned spaceflights. The four experienced astronauts will work closely with the companies Boeing and SpaceX to develop the companies' crewed spaceflight capabilities.

The selection is part of NASA's Commercial Crew Program, where the agency works with private companies to provide crew transportation systems and services from the US.

"Naming these astronauts is a key step forward and consistent with past approaches to involve the crew in the design and development of new systems," says Kathy Lueders, manager of the Commercial Crew Program.

VENUS'S ATMOSPHERE STUDIED FROM TRANSIT IMAGES

The atmosphere of Venus has been studied from images taken during its solar transit in 2012. The technique maps sunlight as it travels through the layers of the planet's atmosphere and could be applied to exoplanets.

NASA/JAMES BLAIR, NASA/GODDARD/SDO, ISTOCK, NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA), NASA/JPL/SPACE SCIENCE INSTITUTE

New age for globular formation

The clusters may have formed later than previously believed

▲ **Globular clusters were thought to have formed much earlier than this latest research suggests**

GLOBULAR CLUSTERS MAY have formed in two distinct periods – 12.5 and 11.5 billion years ago – making them slightly younger than previously thought.

"We now think that globular clusters formed alongside galaxies rather than significantly before them," says Prof Duncan Forbes of Swinburne University of Technology, who led the research. His team's observations, made using the Keck II telescope in Hawaii, pinned down the age of globulars by comparing their chemical composition to that of the Universe as it changed over time.

"Now that we have estimated when globular clusters form, we next need to tackle the questions of where and how they formed," says Forbes.

www.keckobservatory.org

WHEN GALACTIC GIANTS MEET DWARFS

WHEN TWO GALAXIES of different sizes collide, the larger one stops the smaller from forming stars. This conclusion from a study of more than 20,000 galaxies marks a departure from what happens when two equally sized galaxies collide – in that instance, the rate of star birth increases in both.

"When one galaxy significantly outweighs the other, we have found that star formation rates are affected for both, just in different ways," says Luke Davies from the University of Western Australia. "This might be because the bigger galaxy strips away its smaller companion's gas, leaving it without star-forming fuel, or because it stops the smaller galaxy obtaining the new gas required to form more stars."

http://www.icrar.org

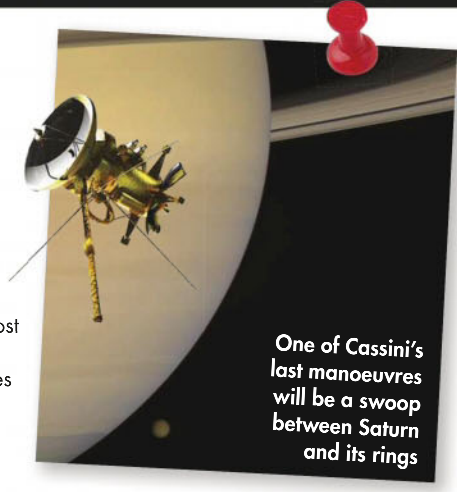
The larger of the two interacting galaxies in rose-like Arp 273 may be stifling star formation in the other

Looking back The Sky at Night

September 1997

On 21 September 1997 the team were looking forward to the launch of the Cassini-Huygens mission to Saturn. It launched successfully on 15 October, but it would take another seven years for the probe to reach the planet. On Christmas Day 2004, the Huygens lander separated from the Cassini orbiter and began its descent to Saturn's largest moon, Titan.

For over 10 years Cassini has been sending back images of the planet, its rings and moons. But now it is reaching the end of its life. In late 2016, the probe will use its final flyby of Titan to adjust its orbit so that it passes high over Saturn's north pole, and will then attempt to pass through the gap between the planet and its innermost ring. It's uncertain if the probe will survive the manoeuvre, but if it does it should finally allow scientists to calculate the mass of Saturn's most distinctive feature – its rings.



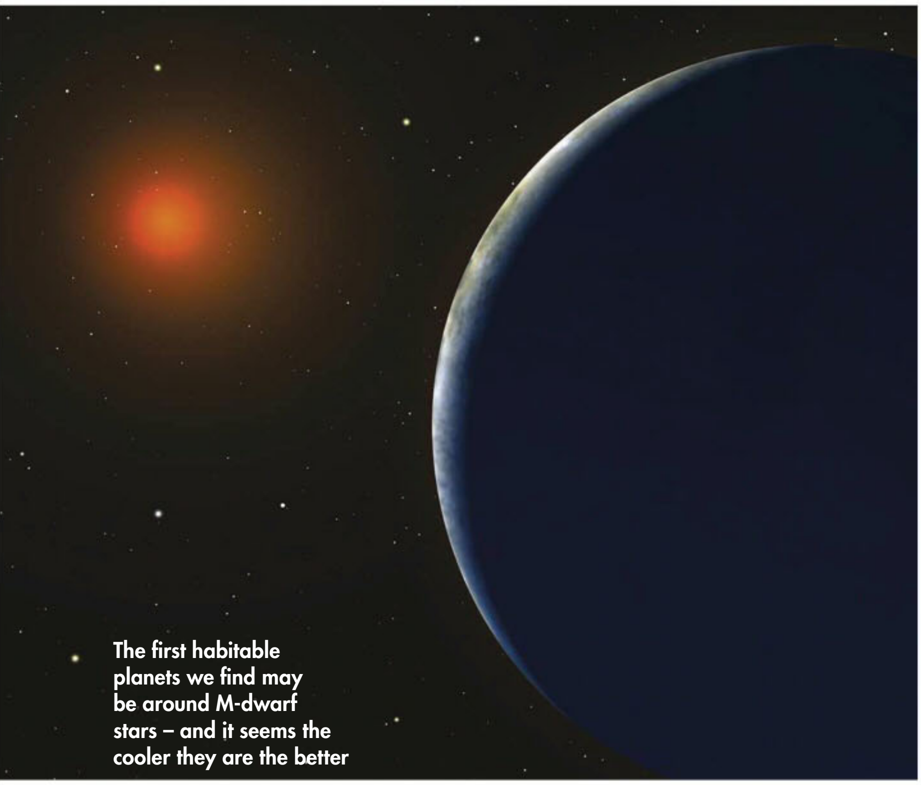
One of Cassini's last manoeuvres will be a swoop between Saturn and its rings

CUTTING EDGE

Our experts examine the hottest new research

Can stars hide life's signs?

The first hint of life somewhere beyond Earth may be found on a world under a blood red sky



The first habitable planets we find may be around M-dwarf stars – and it seems the cooler they are the better

To date, nearly 2,000 confirmed exoplanets have been discovered around other stars – we now know that when you gaze up to the heavens you're not just looking at stars, but towards multitudes of planetary systems.

Some of these exoplanets are thought to be rocky terrestrial worlds orbiting in the habitable zone of their stars, potential abodes for alien life. The next step, and one we are right on the brink of, is to begin surveying these most Earth-like planets for the tell-tale signs in their atmospheres that they host life. For example, the atmospheric biosignature talked about most often is detecting oxygen gas (or rather, the ozone gas produced from it, which turns out to be easier to detect in a light spectrum) along with something like methane. The two should readily react and remove each other from the atmosphere, so finding alien air so far out of chemical equilibrium would imply that a biosphere is releasing these gases at a significant rate.

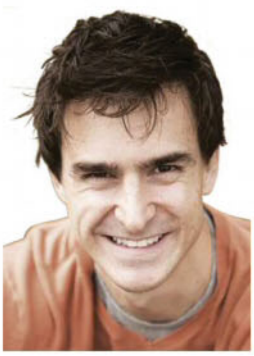
Cool, red, M-class dwarf stars not only make up around three-quarters of the closest stars to us, but their relative dimness also makes it easier for us to find planets orbiting in their habitable zones. So it is likely that the first habitable exoplanets to be checked for life will be those huddled close to M-dwarfs. But what, asks Sara Rugheimer and her colleagues in a recent paper, would be the effects of the ultraviolet emissions from M-dwarfs on the detectability of these atmospheric biosignatures?

Rugheimer and colleagues used a computer model of planetary atmospheres to determine how easy it will be to pick up various biosignatures around the full range of M-dwarfs using the James Webb Space Telescope or ground-based observatories like the E-ELT. They found that the varying ultraviolet emissions from the range of M-dwarf stars made significant differences to the abundance of different gases in an exoplanet's atmosphere and their detectability in the spectrum. Active M-dwarfs with lots of flares made the ozone signature easier to detect, but decreased the amount of methane in the planet's atmosphere (destroying it

> "Active M-dwarfs made the ozone easier to detect, but decreased methane in the atmosphere"

with high ultraviolet emissions), and so may mask the presence of life. On the other hand, cooler and less active M-dwarfs emit very little ultraviolet radiation. In this case, molecules such as methane and nitrous oxide are able to build to high levels.

Rugheimer points out that detecting nitrous oxide would constitute a particularly good biosignature as there are no known photochemical sources of the gas. This biosignature would be undetectable for planets around hotter stars like our Sun, as they emit more destructive ultraviolet light. So not only are habitable planets much easier to spot orbiting M-dwarfs, the low ultraviolet emissions of the less active stars will also make it easier to spot certain atmospheric biosignatures. The first signs of extraterrestrial life may well be discovered on worlds with a blood red sun hanging in their skies.



LEWIS DARTNELL is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *Effect of UV radiation on the spectral fingerprints of Earth-like planets orbiting M Dwarfs* by S Rugheimer, L Kaltenegger, A Segura, J Linsky and S Mohanty

Read it online at http://arxiv.org/abs/1506.07202

What's on

Our pick of the best events from around the UK

Astronomy Photographer of the Year 2015

PICK OF THE MONTH

Royal Observatory Greenwich, London, from 18 September

▲ **Get inspired by this year's selection of astro images taken by amateurs worldwide**

This year's Insight Astronomy Photographer of the Year competition welcomed over 2,700 images by astrophotographers from 60 countries. This year's judges included comedian, amateur astronomer and *BBC Sky at Night Magazine* columnist Jon Culshaw, *BBC Sky at Night Magazine* editor Chris Bramley and Royal Observatory Public Astronomer Dr Marek Kukula. With an expanded list of categories – there are now seven, plus two special prizes and the young astronomer competition – the 2015 entrants had even more opportunity to dazzle the judges.

The winning entries are due to be announced on 17 September and will then be displayed at the observatory's Astronomy Centre from the following day. The competition promises to be an impressive showcase of the photographic talents currently working in astro imaging, as well as a reminder of the majesty and beauty present throughout the Universe.

The exhibition is free to enter during the observatory's normal opening hours. To find out more and see some of the shortlisted images, visit the competition website.
www.rmg.co.uk/astrophoto

BEHIND THE SCENES

THE SKY AT NIGHT IN SEPTEMBER

BBC Four, **13 September,** 10pm (first repeat BBC Four, **Thursday 17 September,** 7.30pm)*

The giant planets of our Solar System had a role to play in its current layout

OUR CHANGING SOLAR SYSTEM

This month *The Sky at Night* reveals how the night sky changes with time. The team explore the latest theories on Solar System evolution, how the layout of the Solar System was created by a dance between the giant planets that left scars we can see today and how the same process plays out in bizarre ways around other planets.

***Check www.bbc.co.uk/skyatnight for subsequent repeat times**

ROYAL OBSERVATORY GREENWICH, ISTOCK, STATE MUSEUM AND EXHIBITION CENTER ROSIZO, ESA/HUBBLE & NASA, D-KURU

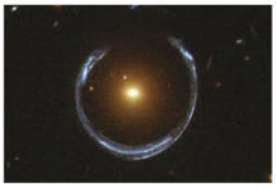
Cosmonauts: Birth of the Space Age

The Science Museum, London, from 18 September

This new exhibition at the Science Museum in London will showcase the largest collection of Russian spacecraft and artefacts ever seen in the UK, including flown Vostok spacecraft. Learn the story of Russia's scientific breakthroughs, from the studies led by 19th-Century cosmists to launching the first artificial satellite, then putting the first animal and human into space. Admission is £14 for adults, concessions available.
www.sciencemuseum.org.uk/cosmonauts

Weak Gravitational Lensing

West Didsbury Astronomical Society, William Hulmes Grammar School, Manchester, 14 September, 7pm



Cosmologist Dr Joe Zuntz of the University of Manchester breaks down the physics behind gravitational lensing, a technique that enables scientists to measure the masses of distant astronomical objects, even if their material composition cannot be determined. It works on the basis that the presence of mass causes light to bend as it passes by on its way to us. The lecture is free to all.
www.wdas2.com

Spectroscopy: Cracking Starlight's Hidden Code

The William Herschel Society, Bath Royal Literary & Scientific Institution, Bath, 4 September, 7.30pm

Spectroscopy was once the domain of professional astronomers, but new advances have brought it within the reach of amateur enthusiasts. Hugh Allen leads this talk on white light's secret code, including practical demonstrations to reveal the hidden stories behind objects in the night sky. Admission is £2 for students and members of the museum or institution, £4 otherwise.
www.williamherschel.org.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.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A PASSION FOR SPACE

with Maggie Aderin-Pocock

The Sky at Night presenter is watching for some of the brightest events in the Universe – gamma-ray bursts

GRBs are brilliant but in many instances brief, with some lasting only a fraction of a second

ISTOCK

When looking at the explosive Universe there is a phenomenon that stands out head and shoulders above the rest. It is so powerful that in a few seconds it gives out orders of magnitude more energy than the Sun will emit in its entire lifetime. It is so bright that all the ones we have observed to date have been located in other galaxies. The majority of the radiation released in this type of explosion is in the form of the most highly energetic wave in the electromagnetic spectrum – gamma rays. I am talking about gamma-ray bursts. But what are these incredibly bright events?

In terms of observation a gamma-ray burst, or GRB, is an incredibly intense flash of gamma radiation. The shortest last just a fraction of a second, though some can go on for a few minutes and we have even seen some that last for a few hours, though this is very rare. When a GRB occurs it is one of the brightest things in the sky. We observe around 100 GRBs a year but, because of their directional nature, this is probably only around 10 per cent of the total that is occurring within our observable range.

After the burst of gamma rays an afterglow is often observed that contains other parts of the electromagnetic spectrum and lasts a lot longer than the initial burst.

Where do they come from?

There has been some debate as to what causes GRBs. Short-lived ones are thought to be caused by collisions between massive objects such as neutron stars or black holes. Longer-lived bursts (two seconds or longer) are thought to be from the collapse of stars with 30 or more solar masses.

These collapses have sometimes been associated with supernovae, but there is only limited evidence. When observed in distant galaxies, though the GRBs may be clearly visible, any accompanying supernova would be much dimmer, meaning it is rarely detectable over the distances involved.

The GRBs that have been observed have all been far from our Galaxy, and as a result the light has taken a long time to reach us. These explosions took place when the Universe was very young, around four per cent of its current age. As a result we are looking at the demise of objects that were some of the first stars formed in our Universe. GRBs are so bright that they excite the matter surrounding these early stars. As we develop more sophisticated detection equipment, GRBs will give us insight into the environment that the early stars were created in.

The fact that we have only detected GRBs beyond our Galaxy is actually a comfort. Due to the energies released, if one did erupt in our Galaxy the levels of radiation could have an impact on life on Earth. Luckily calculations have shown that it is extremely unlikely for one to occur in the Milky Way. The conditions just aren't right.

In the explosive stakes GRBs are really out there. By looking at these great bright sparks, we may get a better understanding of what it was like in the early Universe.

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

JON CULSHAW'S EXOPLANET EXCURSIONS

Jon travels to a world that's leaving a wake like a comet approaching perihelion

Everyone was so heartened to hear Philae had reawakened upon its comet, albeit at the funny angle at which it came to rest. The prospect of viewing a comet as it goes into full fizz around our Sun, from the surface of that very comet, is one of wonderful anticipation.

It brings to mind the days when my Dad used to service an industrial package boiler at a mushroom farm. Every so often he needed to 'crank a steam valve' to clear the system. At this moment a monumental column of piping hot vapour emerged from a dented chimney pipe with such force it resembled a giant cumulus cloud being instantly spaghettified. This is how I imagine it would look standing on a comet's surface and looking back along the tail.

To observe similar phenomena on an immensely larger scale I'm journeying to the constellation of Leo, 33 lightyears from Earth, and the red dwarf star Gliese 436. It seems a frail little star, billions of years older than our Sun, much fainter and just 42 per cent the radius. It defiantly shines with a magnitude of +10.6.

Orbiting the star is a planet of a similar scale to Uranus named Gliese 436 b. This world has been the focus of a fair amount of attention recently. Perhaps this ice giant is undergoing a sort of planetary migration, with an orbital path skewed so that it is inexorably spiralling towards its parent star. This certainly appears to be what's happening.

Gliese 436 b is very close to its star, completing an orbit in only 2.6 Earth days. This proximity reveals a bite point on the planetary migration path. The outcome is this ice giant's atmosphere is being ruthlessly evaporated by the staggering volumes of radiation and heat. It leaves a colossal wake of boiled-away material stretching far enough to show portions of the planet's orbital track. The atmospheric trail, a brew that is likely to contain hydrogen and carbon monoxide, has shades of petrol blue and slate grey with parts gently reddened by star's glow.

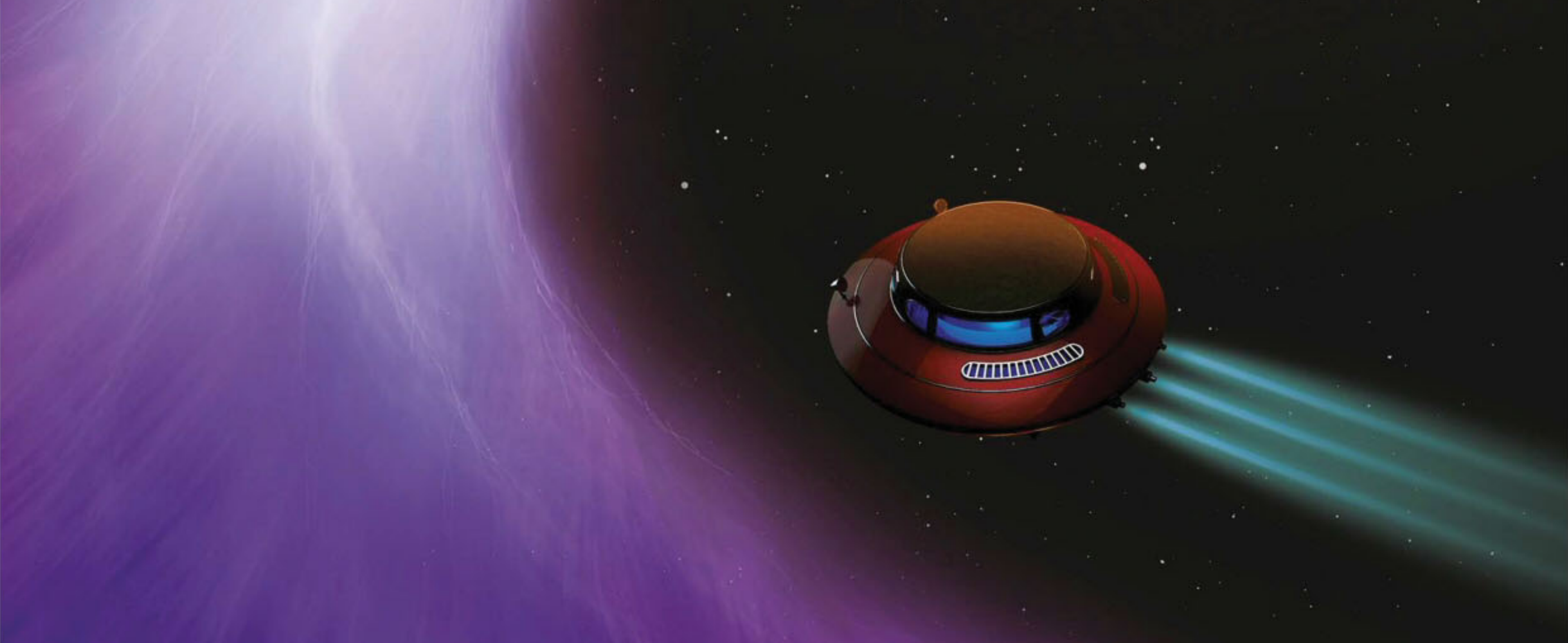
I've always loved observing comets. Hale-Bopp was a perky little stub of a comet, charming and fascinating. It reminded me of a chunky tadpole. Comet C/2006 P1 McNaught on the other hand was majestic – it's not also known as the Great Comet of 2007 for nothing.

Seeing comet-like activity on a scale 22 times the size of Earth is one of the most compelling things we could witness in any star system. It's as though the entire island of Madagascar had morphed into a giant sphere and begun steaming across the Indian Ocean, leaving a wake of unimaginable ferocity. The comets we view from Earth are like clockwork yachts in a bathtub compared to this.

Similar beautiful devastations will befall our Earth when the Sun transforms into a red giant. But let's not dwell on that now.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS



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MESSAGE OF THE MONTH

Pluto as you have never seen it before

I have been interested in astronomy since Sputnik 1 sparked my interest while I was at school. After watching *The Sky at Night* special on the New Horizons space probe reaching Pluto and Charon, I took the opportunity to combine this with another of my hobbies, landscape painting. My latest painting is inspired by information gleaned from NASA's latest pictures, especially the icy mountain ranges and the dark coloured areas of Pluto and Charon.

Madaline Clutton, Nantwich

A wonderful painting, Madaline. New Horizons will continue to send back inspiring images as it journeys farther into the Kuiper Belt. **– Ed**

▲ **Madaline's vision of Pluto is rich in colour – we can only hope that the New Horizons images live up to it**

Ice mountain ideas

After seeing the latest pictures of Pluto and hearing about the unexplained ice mountains, I have come up with a suggestion for why these exist. My theory is that because Charon is so large compared to Pluto it could be Charon's gravity pulling the ice up, hence why there are ice mountains.

Amber Rawle, aged 11, via email

As Charon and Pluto are 'locked' together, scientists thought its gravitational influence had ended. Yet all we really know at the moment is that Pluto is mysterious. It's time for new ideas - and yours is worth considering! **– Chris Lintott**

Light panel shortcuts

Having read with interest the article on making a light panel (*How to*, August, page 82), it occurred to me how similar this device is to a tablet screen. I looked on the Google Play store and sure enough, there is a free lightbox app that does the trick.

Paul Julier, via email

You can also use a backlit laptop screen with the Notebook application running. However, the RGB matrix over the laptop screen could affect the fidelity of the light source, unless you're sure that the panel is at right angles to the telescope's axis. Also, some laptop and tablet screens do not have very even illumination. **– Steve Richards**

No cheerleaders here

While we're pleased that Emily Winterburn finds our newly published *The Secret Life of Space* "a great introduction to major stories" (*Books*, August page 102), we're disappointed that she takes us to task for not featuring female astronomers more highly.

The book is aimed at general readers: it blows away misconceptions behind many of astronomy's myths. Devoting one-third of the review to female astronomers completely misses the point of *Secret Life of Space*! In fact, we don't treat them as mere "cheerleaders": we emphasise, for instance, the major roles of Cecilia Payne-Gaposchkin (finding that hydrogen is the main constituent of the Universe) and Vera Rubin (discovery of dark matter). We actually devote more pages to pulsar-discoverer Jocelyn Bell Burnell than to Ptolemy!

It's great that recent astronomy books generally feature a better balance of female to male astronomers. Taking a couple of astronomy history books from our shelves at random, we find the names in a work published in 1961 are only one per cent female; a book from 2008 has four per cent women astronomers; while the proportion of female researchers in ours is over seven per cent.

Nigel Henbest & Heather Couper, by email

This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Heather Couper and Nigel Henbest's *Stargazing 2015*, Patrick Moore's *The Night Sky*, Storm Dunlop's *Practical Astronomy*, and *Stargazing with Binoculars* by Robin Scagell and David Frydman.

PHILIP'S

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: Have you ever seen a meteor fireball?

@chunder10 Seen plenty of fireballs, only ever caught one good one on camera. This year two cameras :-)

@Superdavo0001 Seen them? Yep. Photographed them? No. My camera naturally repels them within its FOV :-(

@Steve_P_Knight In 2013 I got a Perseid. The shutter opened during the meteor so you can see the ionisation trail.

Alison Hammond I saw a fireball when travelling in the east end of London one morning. It lasted a few seconds and was very impressive.

BBC

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Hotshots

This month's pick of your very best astrophotos

▲ The Seagull Nebula

BOB FRANKE, CHINE VALLEY, ARIZONA, US, 8 MARCH 2015

Bob says: "Having successfully created a two-panel mosaic, my goal was to then expand to four panels. At the time, the Seagull Nebula or IC 2177 was the perfect target. Modern software makes this type of work much easier. With a total Ha-LRGB exposure of 25 hours, the image assembly came together with no major problems."

Equipment: SBIG STF-8300M CCD camera, Takahashi FSQ-106ED refractor, Losmandy G11 equatorial mount, AstroDon and Baader LRGB filters.

***BBC Sky at Night Magazine* says:** "It's easy to see why IC 2177 is dubbed the Seagull Nebula with the level of detail present in Bob's image. Beyond the scientific value, this astrophoto is aesthetically stunning, as the reds, blues, blacks and whites show off the complexity and beauty apparent in the Universe."

About Bob: "As a young boy in the 1950s I was interested in the usual things: astronomy and dinosaurs. Aged 12, I built a 6-inch reflector but, as I got older, astronomy took a back seat. Just before retirement I took up webcam planetary photography, then my wife and I moved from cloudy Seattle to sunny Arizona. I now do deep-space imaging with two automated observatories in the backyard."

▲ The Eagle Nebula

CHRIS HEAPY, MACCLESFIELD, 8 JUNE 2015

Chris says: "The Eagle Nebula is such a beautiful object. I was lucky to have a few nights of good seeing to capture this image. Narrowband filters helped reduce the effects of atmospheric dispersion."

Equipment: Atik 490EX CCD camera, Tele Vue-NP127is refractor, Losmandy G11 mount, TV Pronto + Lodestar guide.

▲ The Milky Way

PETER LOUER, TENERIFE, SPAIN, 25 JUNE 2015

Peter says: "I needed a reasonable amount of moonlight but without it washing out the sky, so I shot two images; the first a 20-second exposure to get the Milky Way and the other 90 seconds to get detail in the foreground."

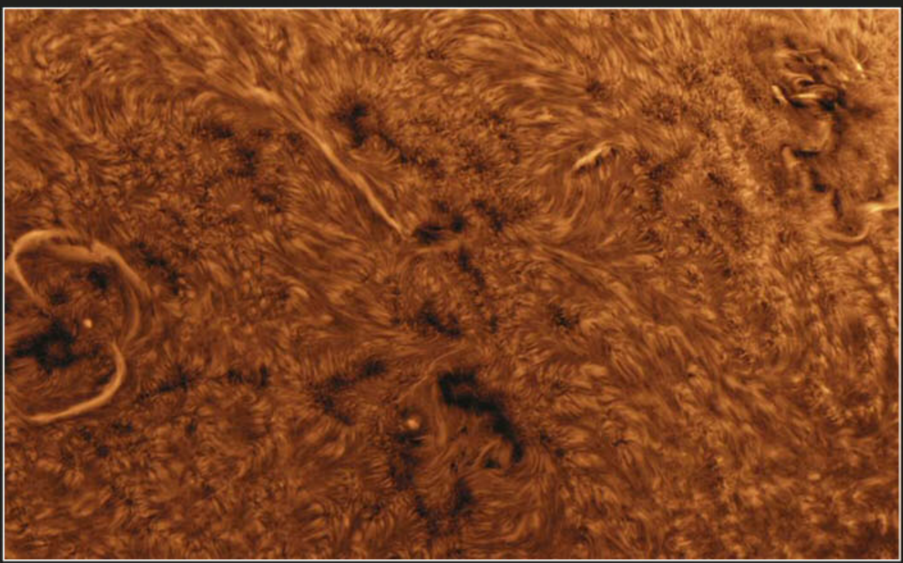
Equipment: Canon EOS 700D DSLR camera, 18-55mm lens.

▶ NGC 6914

ANDRÉ VAN DER HOEVEN/TIM SCHUURMAN, HENDRIK-IDO-AMBACHT, THE NETHERLANDS, 10 JUNE 2015

André says: "Narrowband and colour data was gathered using a CCD camera and combined with DSLR colour data of the central part taken in higher resolution."

Equipment: QSI 583ws mono CCD camera, Canon EOS 350D DSLR camera, Astro-Tech TMB 3.6-inch refractor, 8-inch Newtonian.



◀ Solar active regions

IVAR KOOREN, HEENVLIET, THE NETHERLANDS, 12 JUNE 2015

Ivar says: "What I always like about the Sun is that it is so dynamic. Every week, every day and even every minute it is changing. Because of a lousy summer, I have been on the lookout for gaps between the clouds to shoot some pictures of the most active regions of our star."

Equipment used: ZWO ASI174 monochrome CMOS camera, 4-inch modded PST.

M33 ▶

DAVID MORENO, SPAIN, 25 OCTOBER 2014

David says: "This shot consists of 11 captures of 600 seconds. The globulars associated with M33 are clearly visible, the most prominent being NGC 604."

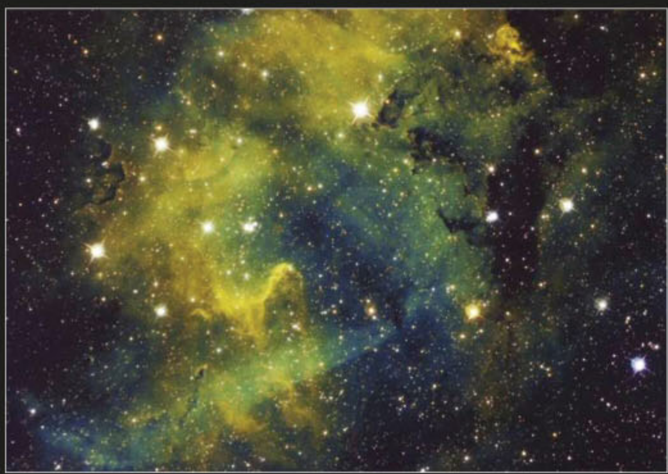
Equipment: Canon EOS 550D DSLR camera, Sky-Watcher 150/750 Newtonian reflector, Sky-Watcher AZ EQ6 Go-To mount.

◀ The North America Nebula

ALASTAIR WOODWARD, DERBY, 11 JUNE 2015

Alastair says: "NGC 7000 is one of my favourite subjects. I imaged the Cygnus Wall last year and have since upgraded my mount, added guiding and modified my DSLR to improve hydrogen-alpha capture."

Equipment: Modded Canon EOS 1000D DSLR camera, Sky-Watcher 150P telescope, HEQ5 Pro mount, QHY5L-II camera, ST80 guidescope.



▲ Emission nebula Sh2-132

MARK GRIFFITH, SWINDON, WILTSHIRE, 13-26 MAY 2015

Mark says: "I wanted to capture an obscure object for a narrowband image and found this on the Sharpless catalogue. I will try more objects in the catalogue if they are going to work out as well as this."

Equipment: Atik 33L+ CCD monochrome camera, 12-inch Ritchey-Chrétien telescope, Sky-Watcher EQ8 mount, Astronomik SII, Ha, OIII filters.

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ENTER TO WIN A PRIZE!

ALTAIR ASTRO

We've joined forces with Altair Astro UK to offer the person behind next month's best *Hotshots* image a fantastic prize. The winner will receive a GP-CAM 120C, 1.2mp colour HD astro camera for Solar System imaging of the Moon, Sun, and planets. www.altairastro.com • 01263 731505

Email your pictures to us at hotshots@skyatnightmagazine.com or enter online.

EXPOSED ASTRONOMY'S GREATEST MYTHS

There are many misconceptions surrounding astronomy. **Mark Garlick** sets some of the biggest right

Astronomy is filled with myths and misconceptions. Despite being based in science and observation, there are several myths that seemingly refuse to go away. From what structures can be seen from the Moon to the ultimate fate of the Sun, there are many falsehoods flying around the field. Here we look at a few of the most persistent astronomical bloopers and go about setting some of them straight.

ABOUT THE WRITER

Mark Garlick is an illustrator, author and member of the International Association of Astronomical Artists.

Our star won't explode – that is the armageddon of science fiction, not science fact

◁ THE SUN WILL ONE DAY 'GO NOVA'

False: Our Solar System's fate is not to end in a cataclysmic explosion

One day, billions of years from now, the Sun will suddenly explode as a nova, taking with it the Earth and all its life. At least, it will according to some particularly painful science-fiction movies. Emphasis on fiction. It is impossible for a solitary star to 'go nova' and the Sun's ultimate fate is a far more sedate affair.

Astronomers have long known of stars that seem to appear in the sky as if by magic. They dubbed them 'novae' (singular nova), which stems from the Latin for 'new'. What is actually happening is that an object too faint to be seen has undergone a dramatic increase in brightness. Since the 1950s we have known that this event, a nova outburst, can only happen in closely interacting binary stars called cataclysmic variables. A small, dim star called a red dwarf transfers matter to a compact stellar corpse, a white dwarf. This transferred material accumulates around the white dwarf and then one day ignites in a thermonuclear event, increasing the system's brightness by orders of magnitude. A nova is born. The white dwarf survives, and immediately begins to accrete more gas, restarting the whole process.

However, the Sun has no companion to feed it. Instead, when it finally runs out of fuel with which to stoke its nuclear fires it will gradually expand into a red giant, puffing out its atmosphere until it turns into a white dwarf. The fate of our star ends with a whimper, not with a bang.

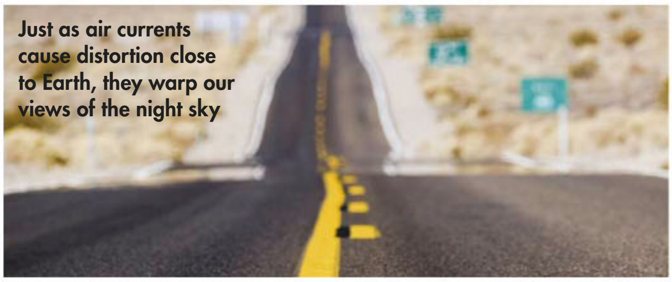
▽ PLANETS DON'T TWINKLE

False: Not even the planets can escape the whims of Earth's atmosphere

Sometimes stars can appear to flicker, winking on and off. This is called twinkling. But what about those 'stars' that appear to shine steadily, unaffected by this phenomenon? A know-it-all might point out that it must be a planet, because "planets don't twinkle".

But sometimes, planets twinkle too. Twinkling is a result of turbulence in our atmosphere. Our sky has many layers, each with varying densities and temperature profiles. Ever noticed how the road shimmers in the distance on a hot day? That's because the tarmac heats the air immediately above it and causes the air to move, so distorting the image of the road. Twinkling is similar. Stars, even under the highest magnifications, are just points. Atmospheric turbulence easily affects their appearance and causes them to wink on and off, jump around and change colour.

Planets, however, have discernible discs through telescopes and some binoculars. So it takes a lot more turbulence to change the shape of the disc or snuff it out completely. It can happen, though, when the sky is especially turbulent – around the time of a thunderstorm, for instance. And if the planet is particularly small in the sky, it will be more readily affected by twinkling. ▸



Just as air currents cause distortion close to Earth, they warp our views of the night sky

MARK GARLICK/SCIENCE PHOTO LIBRARY, ISTOCK X 2

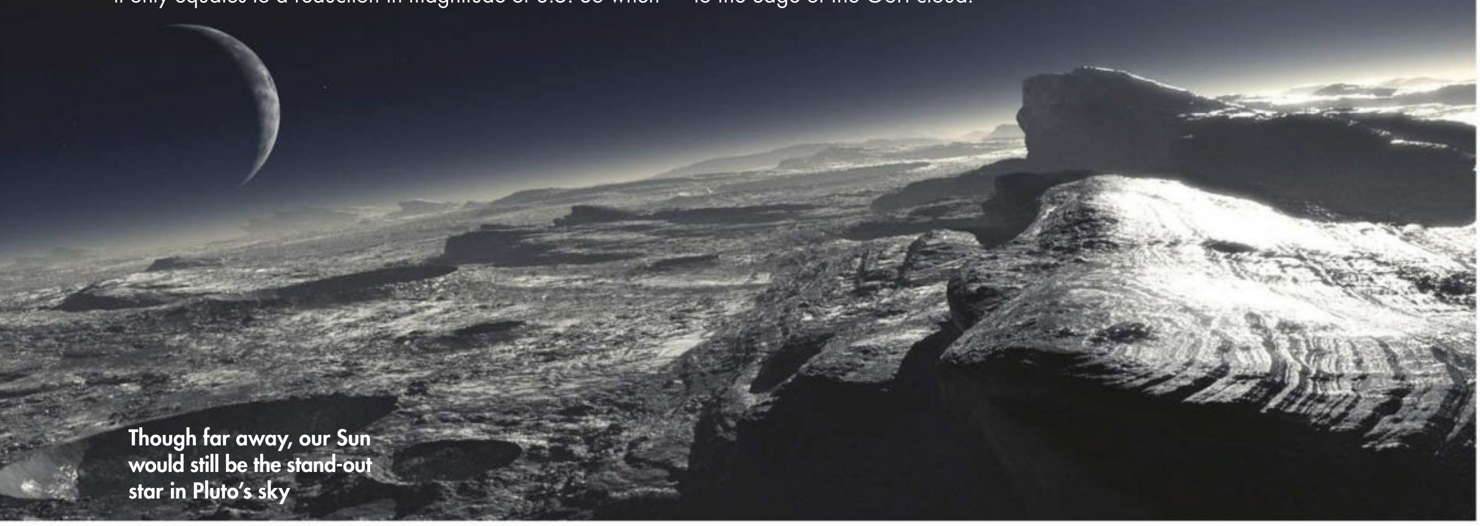
▽ THE SUN IS JUST ANOTHER STAR FROM PLUTO

False: You would have to be much farther for the Sun to blend into the background

It's unsurprising that the myth of how bright the Sun appears on Pluto has perpetuated when you consider the vast distance to the dwarf planet; 6 billion km (Pluto's average distance) is almost impossibly hard to visualise. When we read that our Sun's intensity is diminished to that of a 'bright star', we imagine it would look something like Venus – brighter than anything except the Moon, but still clearly star-like. This is not the case.

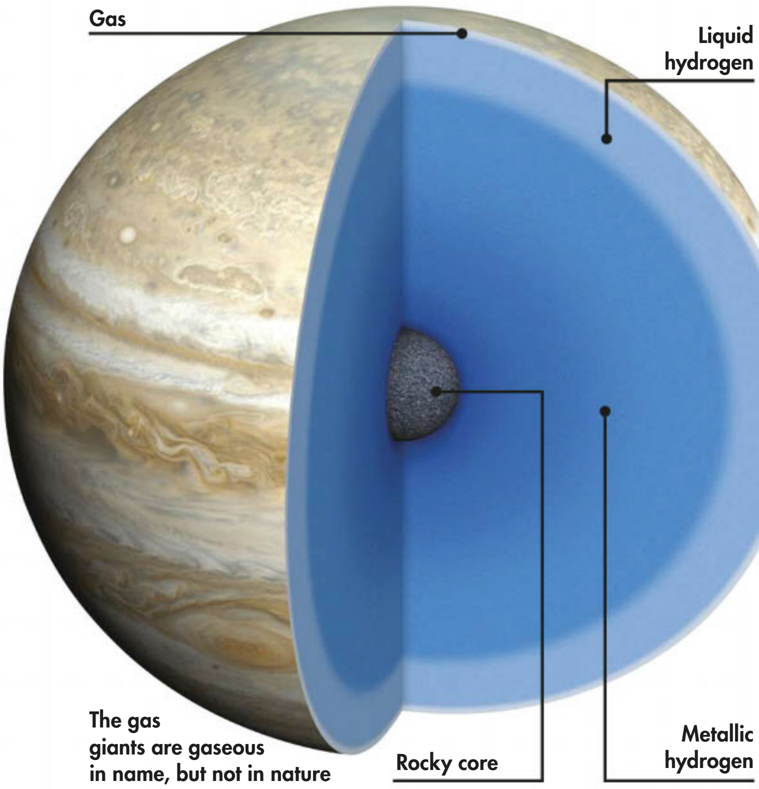
Pluto is, at its farthest, 50 times farther from the Sun than the Earth is. The inverse-square law, which tells us how the brightness of an object falls away with distance, tells us that from such a remote locale, the Sun is 2,500 times fainter than from Earth. That may seem like a lot, but it only equates to a reduction in magnitude of 8.5. So when Pluto is at its farthest, the apparent magnitude of the Sun drops from –26.7 on Earth to just –18.2. That is still 5.5 magnitudes brighter than a full Moon. In other words, from 50 AU, the Sun still shines with an intensity equivalent to just under 160 times brighter than a full Moon seen from Earth. When Pluto is nearby at perihelion, a distance of 30 AU, the Sun is as bright as 436 full Moons!

Considering it's possible to read under the light of a single full Moon, several hundred times that was more than enough for New Horizons to image Pluto's surface in July this year. But how far would we need to be from the Sun for it to appear star-like, comparable to Venus? The answer is around 0.43 lightyears – about halfway to the edge of the Oort cloud.



Though far away, our Sun would still be the stand-out star in Pluto's sky

▽ GAS GIANTS ARE MADE OF GAS

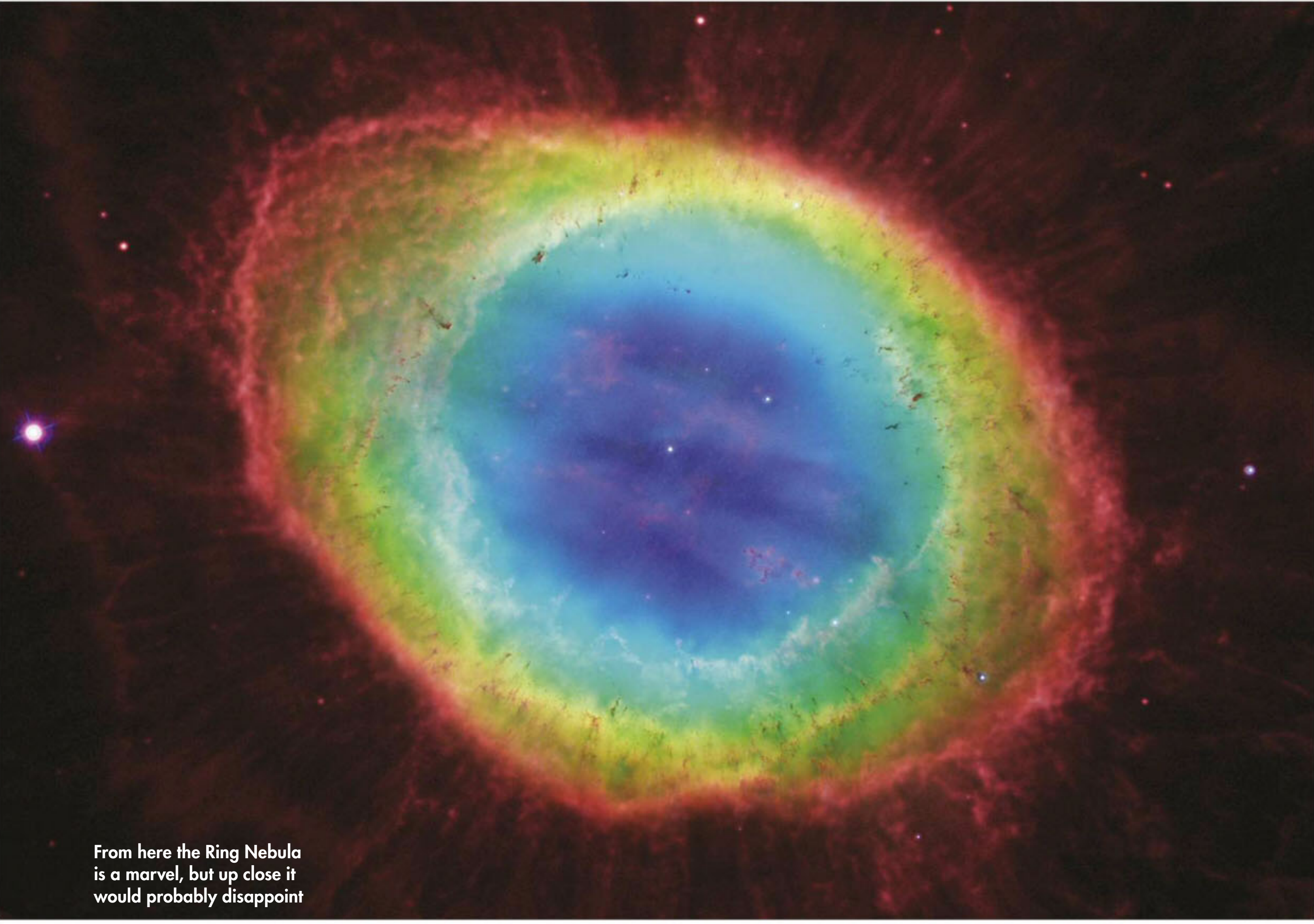


The gas giants are gaseous in name, but not in nature

False (sort of): The pressure of the giant planets makes 'gases' behave differently

This is more of misnomer than a misconception: the gas giant planets, Jupiter and Saturn, are indeed made of substances that we would – under everyday conditions on Earth – call gases. The primary constituents, just as in stars, are hydrogen and helium. Where the misunderstanding comes in is that, under the extreme conditions present within the interiors of these planets, these substances look and behave nothing like the gases we use to fill balloons (helium) or ill-fated airships (hydrogen, which is highly explosive).

The outer atmosphere of a gas giant is indeed gaseous, composed mostly of hydrogen and helium in a form we are most familiar with. But beneath this layer the density starts to increase substantially, forming a thick blanket of 'liquid' hydrogen. It's no longer a gas, but instead behaves like a fluid. As the depth below the surface increases, so does the pressure, growing to millions of times higher than under a terrestrial sky, and the liquid hydrogen transitions to a substance called metallic hydrogen – a special form of liquid hydrogen that occupies most of the interior of the planet. Its density is so high that the material becomes an excellent electrical conductor, like certain metals. It may even be a superconductor, conducting electricity with zero electrical resistance. At the very centre of the planet lies a rocky core between 10 and 20 times the mass of Earth. Thus the interior of a gas giant is a vast, spinning, electrically charged slush – which is the mechanism behind Jupiter's powerful magnetic field.



From here the Ring Nebula is a marvel, but up close it would probably disappoint

△ NEBULAE WOULD LOOK STUNNING UP CLOSE

False: Interstellar travel would not be as beautiful as some films predict

This misconception probably stems from the countless beautiful photographs of galaxies and nebulae that highly sensitive cameras and software can create. In addition, astronomical artists such as myself are very good at augmenting the brightness of nebulae in their illustrations – otherwise our images would look rather boring!

Consider the Orion Nebula, clearly visible to the naked eye as a bright smudge on the sky. It's easy to imagine that, if we were right next to it, it would probably look pretty amazing. But the truth, sadly, is rather more prosaic, and this is because nebulae and galaxies have intrinsically low surface brightnesses. The closer you get to a nebula, the bigger it appears, yes, but the more spread out its light becomes. In fact if we could visit the epicentre of a typical planetary nebula – the famous Ring Nebula say – we wouldn't even know we were there. We might expect the entire sky to glow, filled as it is with ionised gases, but there would be nothing to see. Nebulae look stunning in photos because they compress lightyears into inches, and because cameras accumulate light. The longer the camera shutter stays open, the brighter the photo becomes. I once painted the Horsehead Nebula in Orion as filling the sky of an alien planet. It looked like a lovely place to visit – but it was pure fantasy.

THE MOON IS ONLY VISIBLE AT NIGHT ▷

False: It can frequently be seen during daylight

Some might imagine that the Moon belongs to the night – that it is something that comes out when the Sun goes down, just like the stars. The truth is that the Moon is in our skies as often as the Sun is. Sometimes it is at night, and sometimes it is during the day. It's just that at night, it is much easier to spot.

The Sun, Moon, planets and stars all appear to move across the sky because Earth is rotating on its axis, completing a full turn in 24 hours. When Earth turns away from the Sun, it sets and we don't see it again for several hours. It's no different for the Moon, which is subject to the same pattern of rising and setting as the Sun and all other celestial bodies, but the time between successive moonrises is slightly more than 24 hours. This means that the time the Moon comes up creeps forward every day and sometimes falls within the daylight hours. The Sun drowns out the stars, but when the Moon is up it is easily visible during the day – so long as it is not too close to the Sun, when it will have a very narrow crescent or new phase. ▸

▸ The Moon is not as obvious in daylight skies, but easy to see if you know where to look

ESO/L. CALCADA, MARK GARLICK/SCIENCE PHOTO LIBRARY, NASA/ESA/C.R. O'DELL (VANDERBILT UNIVERSITY) AND D. THOMPSON (LARGE BINOCULAR TELESCOPE OBSERVATORY), ISTOCK

Forget seeing the Great Wall from the Moon; it is barely visible from the Kármán line at 100km

THE GREAT WALL OF CHINA IS VISIBLE FROM THE MOON

False: Despite its length, the wall is too narrow to see

It's difficult to understand how this myth ever started. Could an object less than 10m wide be visible from the Moon – which at its closest is 363,000km away? Using that width and distance and doing some simple trigonometry reveals that, when the Moon is closest, the Great Wall of China has an apparent size of 0.006 arcseconds. That's like trying to see a human hair from more than 3.5km away. There is no way the human eye can resolve this kind of detail, or, in fact, make out more detail than the vague blurry shape of the continents. Our visual acuity would have to be better by a factor of many thousands.

But what about closer to home, from low-Earth orbit, say? The International Space Station orbits at an altitude of around 400km. From there, the Great Wall is nearly 5 arcseconds wide. That's like a human hair from a distance of around 4m, still too thin for the eye to pick up. And what compounds the issue is that the Great Wall is pretty much the same colour as its surroundings, so the contrast is extremely low. If we descend to an altitude of 100km (the Kármán line, internationally accepted as the beginning of space) then it becomes possible to spot not the Wall itself, but its shadow. But this requires perfect conditions – the Sun has to be low on the horizon, and the atmosphere clear. The Wall itself remains invisible even from this height, except perhaps to a hawk-eyed few.

▽ POLARIS WILL ALWAYS BE THE NORTH STAR

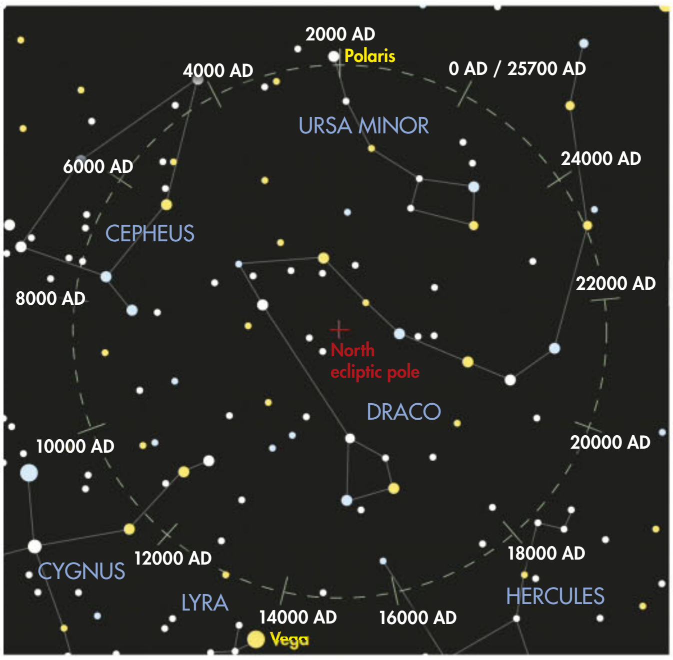
False: Polaris just happens to be in the right place, at the right time

By pure coincidence, our planet's current rotation axis intersects the sky in the north close to an unassuming second-magnitude star named Polaris. This point of intersection is called the north celestial pole. It can be considered the projection of Earth's rotational axis onto the sky.

This means that while the spinning of the Earth appears to make the stars drift across the sky in great arcs, Polaris remains almost fixed. It traces just a tiny circle on the sky around the true north celestial pole, which is about 1° away. In the northern hemisphere it never rises or sets and that makes it useful as a navigational aid. Need to find the north? Look for Polaris.

It is precisely because Polaris is so important that some tend to think that it must also be particularly conspicuous. Yet why would it be? It's just sheer coincidence that Polaris sits practically bang on the north celestial pole. In the southern hemisphere, by contrast, the equivalent of Polaris is a fifth-magnitude star in Octans, barely visible except from a dark sky.

However Earth's rotational axis precesses like a spinning top, making one revolution every 26,000 years. This means that the axis points to different parts of the sky depending on where it is in its precession cycle. In several thousand years' time, Vega – which is one of the brightest stars in the sky – will be the North Star. How's that for coincidence?



▲ Precession means that the pole star will change – it will take around 26,000 years for it to return to the same position it is at today

ISTOCK X 2, CHART SOURCE: LEWIS DARTNELL

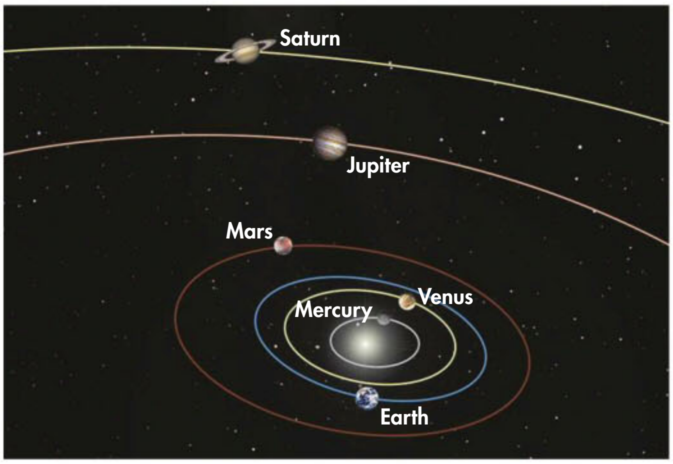
▷ PLANETARY ALIGNMENTS WILL DESTROY THE EARTH

False: Planets coming together are a great astrophoto opportunity, nothing more

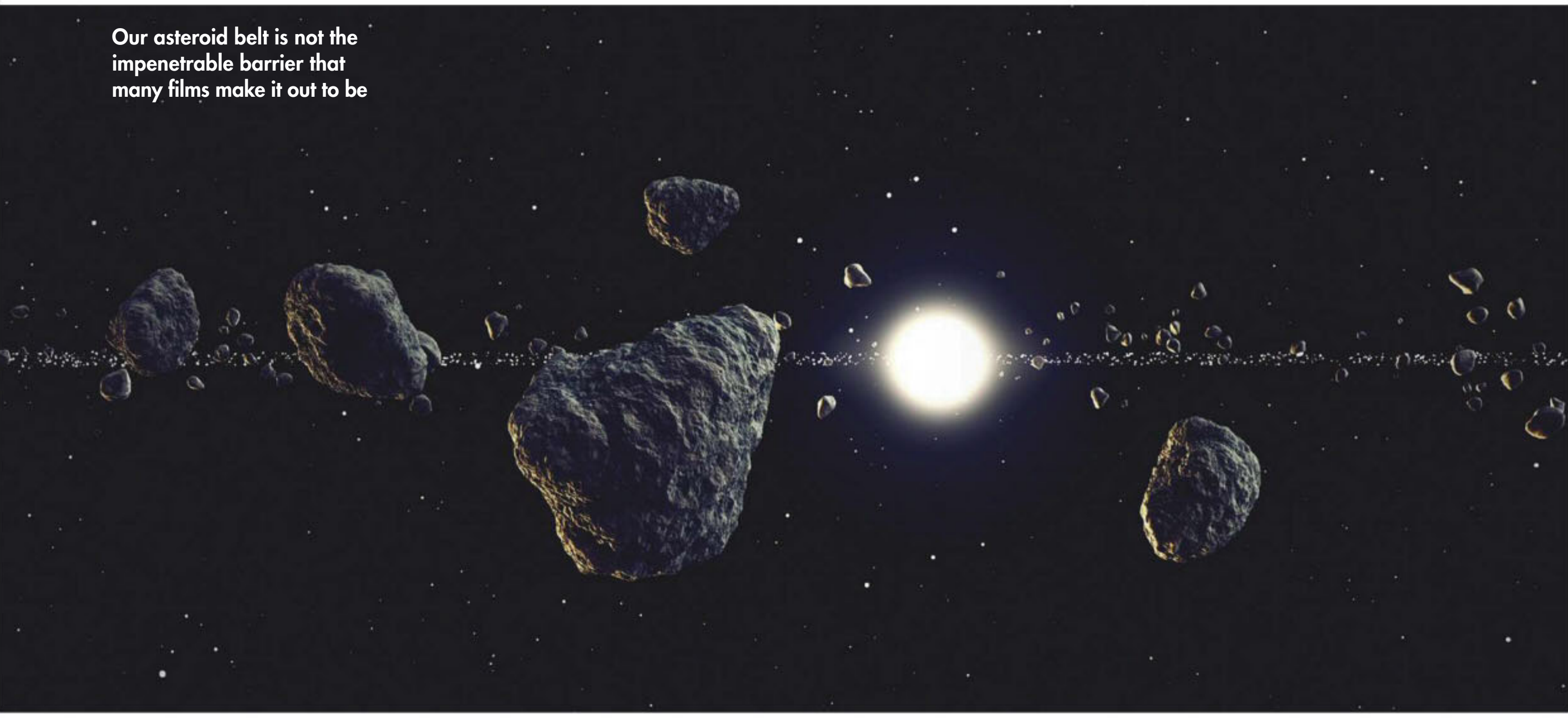
Every so often the planets gather in the sky, and the doomsday folks pop up out of the woodwork to proclaim that the end of the world is nigh. As the planets orbit the Sun, on occasion some of them will gather in an approximation of a straight line spanning the Solar System. As a consequence, they appear in roughly the same place on our sky.

On 5 May 2000, Mercury, Venus, Mars, Saturn and Jupiter were all concentrated within 25° of each other, and some saw this as a portent of doom. They feared that the combined gravity of all of those worlds pulling from the same approximate direction would cause earthquakes, massive tides, even the destruction of Earth. Obviously, that didn't happen or else you wouldn't be reading this article.

It's true that Jupiter and Saturn are huge planets with powerful gravitational pulls. But what matters when talking of gravity or tides is the distance. Jupiter, for example, is so far away that its gravitational pull on Earth, which diminishes according to the inverse-square law, is about one per cent of the Moon's. And the combined tidal force of all the known planets, even when they are as close to us as possible, is thousands of times weaker than the Moon's tides. Given that the Solar System is billions of years old, there have been millions and millions of planetary alignments in our planet's history. And yet we are still here.



▲ **The May 2000 alignment of Mercury, Venus, Mars, Jupiter and Saturn caused some to hail the coming of the apocalypse**



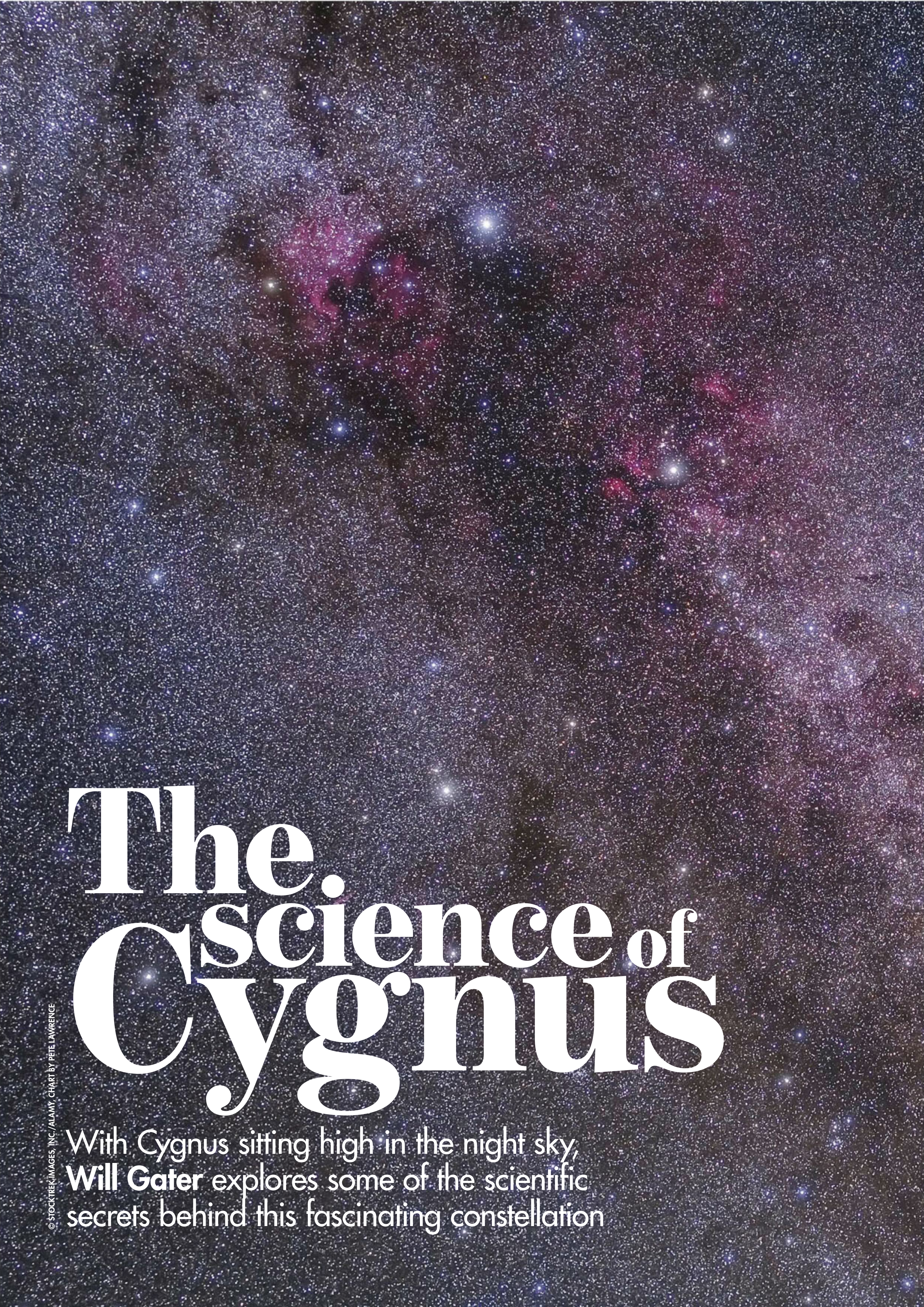
Our asteroid belt is not the impenetrable barrier that many films make it out to be

△ THE ASTEROID BELT IS DENSE

False: On average the space rocks in the asteroid belt are around 600,000km apart

This blatant falsehood is one that can probably be blamed on movies such as *Star Wars*. What sort of hero would Han Solo be if, in evading the clutches of an Empire 'striking back' he dared to take his Millennium Falcon into an asteroid storm and found he had difficulty locating a single object to skilfully dodge? But that is the rather unexciting reality of our asteroid belt. You could sit on an asteroid for decades, and never see a single other space rock close enough to discern its surface. No wonder the film-makers upped the density.

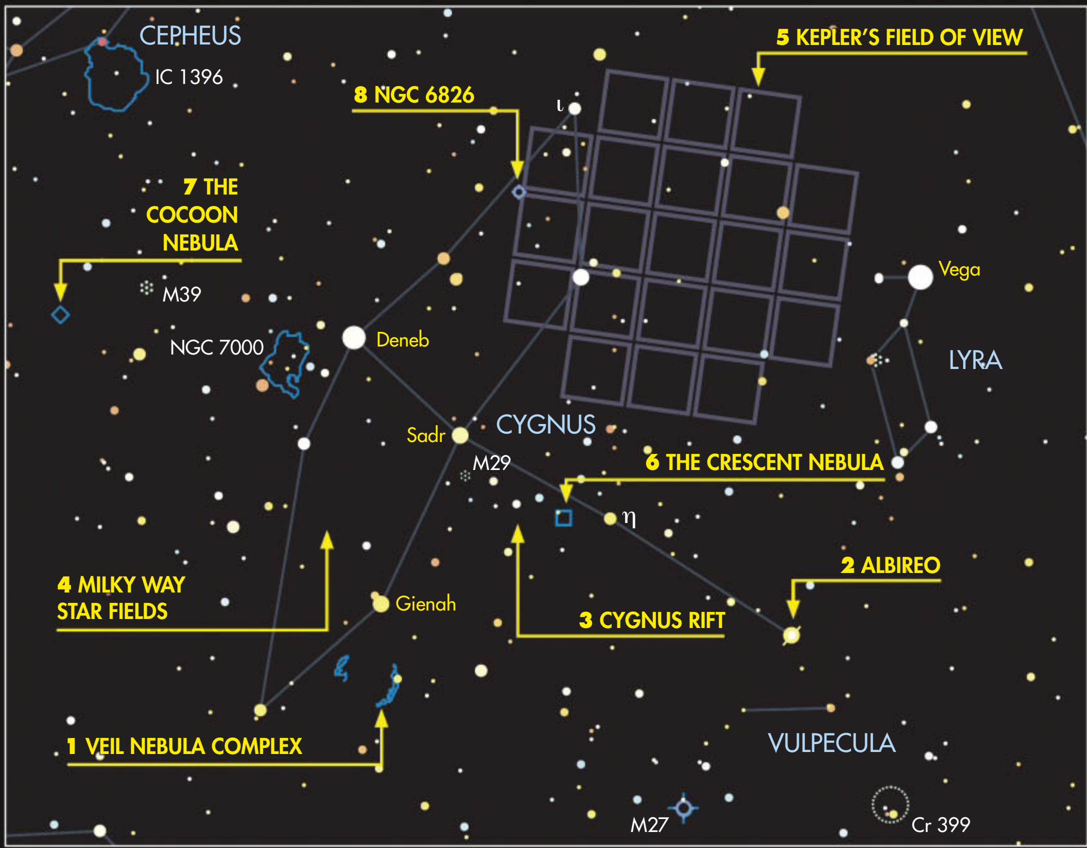
So what is the asteroid belt really like? Well, firstly the belt's mass is puny, only around four per cent that of the Moon. If you could gather all the asteroids together and fuse them into a single super-asteroid, it would probably be no larger than about 1,300km across. That's not much bigger than the largest asteroid, Ceres, which represents a third of the total mass of all asteroids anyway. Second, the asteroid belt is huge. From its inner to its outer edge, it spans a distance greater than the radius of Earth's orbit. That is a lot of space. Now imagine re-pulverising our super-asteroid and sprinkling its debris throughout the asteroid belt. It would be rather like grinding down a marble and distributing its dust over a ring with inner and outer radii of 3.3km and 5.1km respectively. The asteroid belt is very, very sparse.



The science of Cygnus

With Cygnus sitting high in the night sky, **Will Gater** explores some of the scientific secrets behind this fascinating constellation

FIND THE OBJECTS IN THIS FEATURE



The September northern hemisphere night sky is dominated by the magnificent arc of the Milky Way. From the rich star fields of Sagittarius and Scutum all the way to the sparkling clusters of Perseus and Cassiopeia, this enormous swathe of the heavens is bursting with beguiling celestial sights.

Nowhere is this more true than in the beloved summer constellation of Cygnus, the Swan. This striking pattern of stars – with its wings extended in flight across the fuzzy band of the Galaxy – is home to nebulae, clusters and much more. Yet while Cygnus is a treasure trove of sights for us amateurs to enjoy, there are also some remarkable stories of science to be found in this iconic patch of sky, and it's these we'll explore here. From alien worlds to stellar skeletons, you'll never look at Cygnus in quite the same way again. ▸

ABOUT THE WRITER

Will Gater (@willgater) is an astronomer and writer. He is the author of several books and presents live astronomy shows for Slooh.

The Veil Nebula Complex is so large that several of its regions are recognised as separate nebulae; one of the most famous is the Witch's Broom Nebula, far right

1. The Veil Nebula Complex

The science: This is an extensive supernova remnant – the scattered remains of a long-dead massive star.
Where is it? In the 'wing' of the Swan, about 2° from the second-magnitude star Gienah (Epsilon Cygni).

We begin our tour through the scientific secrets of Cygnus not with the multitudes of living stars that inhabit this region but in the realm of the dead – specifically the glowing skeleton of a dead star. Follow Cygnus's 'wing' southeast from mag. +2.2 Sadr (Gamma Cygni) and you'll come to a mag. +2.5 star known as Gienah (Epsilon Cygni). A few degrees further southeast from there you'll find our first object – the beautiful Veil Nebula Complex.

This sprawling complex of intricate gas clouds is a tricky target to see visually, but a favourite object for astro imagers at this time of year. It is what's left when a massive star dies in a supernova. The explosion rips the star apart, throwing vast clouds of gas and dust across space; these carry on glowing dimly long after the explosion, and that's what we're seeing in the Veil Nebula Complex today.

We have much to thank supernovae for. The heavier elements needed to make planets like Earth, and life itself, were created in the swansongs of massive stars. Without supernovae to help forge and scatter this material across the cosmos, we could never exist.

Albireo's colour-contrasting components make it a great observing target

2. Albireo

The science: A famous double star with a striking colour difference between its primary and secondary components.
Where is it? At the head of the Swan, close to the border between Cygnus and the neighbouring faint constellation of Vulpecula.

Cast your eyes around the summer night sky and you'll see that many show slight tinges of colour. We're not talking about the effect you often see when a bright star is low down on the horizon – where the star appears to flash in a variety of colours as Earth's atmosphere refracts and distorts its light – but real colour differences.

Orange-red Antares (Alpha Scorpii) has perhaps the most striking colour to the naked eye at this time of year, but in Cygnus there's a wonderful telescopic example: the double star Albireo (Beta Cygni). It appears as a single star to the eye alone, but through a telescope and high-power eyepiece you'll see two stars – one gold and the other blue, like a sapphire.

These colour variations are down to the temperature. Hotter stars shine with a blue or white tint, while cooler stars appear more yellow, or even red.

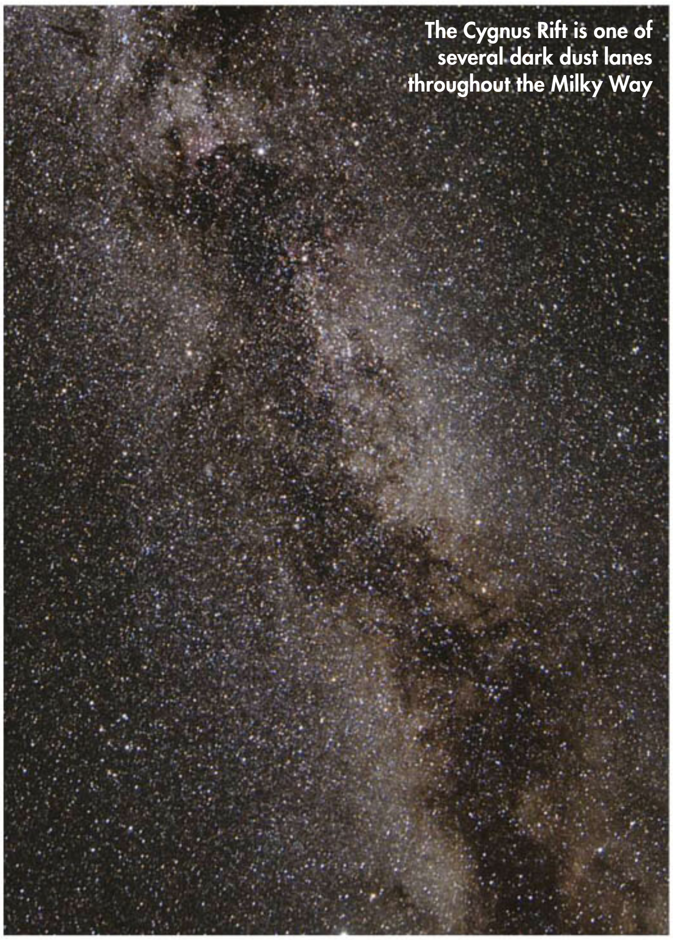
3. The Cygnus Rift

The science: A dust lane that cuts right through Cygnus – just one of the many dust lanes visible in the Milky Way.
Where is it? Across the whole constellation and through the southern 'wing' of the Swan.

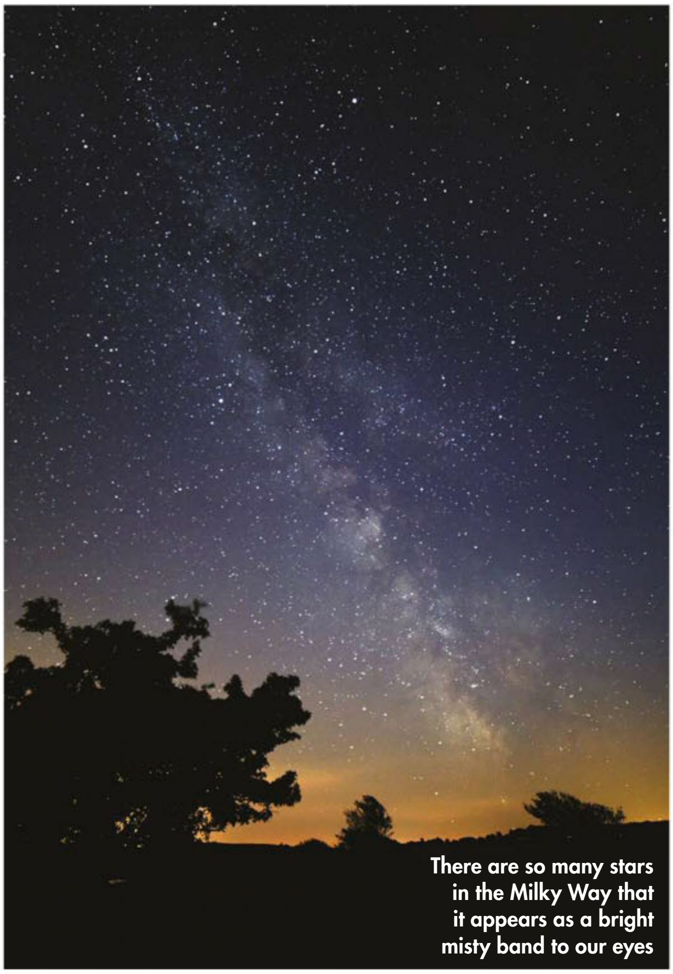
On a really clear night, and after allowing sufficient time for your eyes to become dark adapted, the part of the Milky Way that runs through Cygnus is very obvious. But look carefully and you'll also see another, slightly subtler, feature of our Galaxy's fuzzy path in this part of the night sky. Across the constellation, and indeed all the way through much of the summer Milky Way, are dark swathes of sky – black regions where it appears as if the gentle glow of the stars is largely absent.

The truth is you're not actually seeing an absence of stars. What you're seeing are vast clouds of interstellar dust and gas that are blocking out the light from the more distant background stars of the Galaxy. The most famous of these dark 'dust lanes' – as they are known – in this region is the magnificent Cygnus Rift. It traverses practically the entire constellation and extends, as part of the 'Great Rift', into the neighbouring constellation of Vulpecula, to the south, and beyond.

As it winds roughly north-east through Cygnus, the Rift appears to be broken by a star field near mag. +1.3 Deneb (Alpha Cygni). Nevertheless, you'll still find many large, dark patches beyond this area, in the direction of the constellation of Cepheus.



The Cygnus Rift is one of several dark dust lanes throughout the Milky Way



There are so many stars in the Milky Way that it appears as a bright misty band to our eyes

4. The star fields of the Milky Way

The science: The light of millions of stars blended together to form a misty band across the night sky.
Where is it? All through Cygnus from Albireo (Beta Cygni) to the border with Cepheus and Lacerta, and beyond.

Our Galaxy is thought to be composed of somewhere between 200-400 billion stars. When we look up into the sky around this time of year we can get a fairly good idea of how those stars are distributed.

The constellation of Cygnus is one of the many constellations through which that famous band of light we call the Milky Way runs. What we're seeing when we look at this dim glow is the combined light of many millions of stars; they are so numerous and so distant that their light appears blurred into one faint stream that meanders across the sky. The stars that sparkle seemingly on their own in the sky are merely nearby stars in the Galaxy's vast disc. Indeed, the Milky Way that passes through Cygnus is part of the disc too – here we are looking edge-on into the huge spiral arms of stars that are thought to form the principal structures within this disc.

Cast your eye further to the south (from the UK at least), toward the constellations of Ophiuchus and Sagittarius and you can see where the disc of the Milky Way meets the Galaxy's central bulge region.

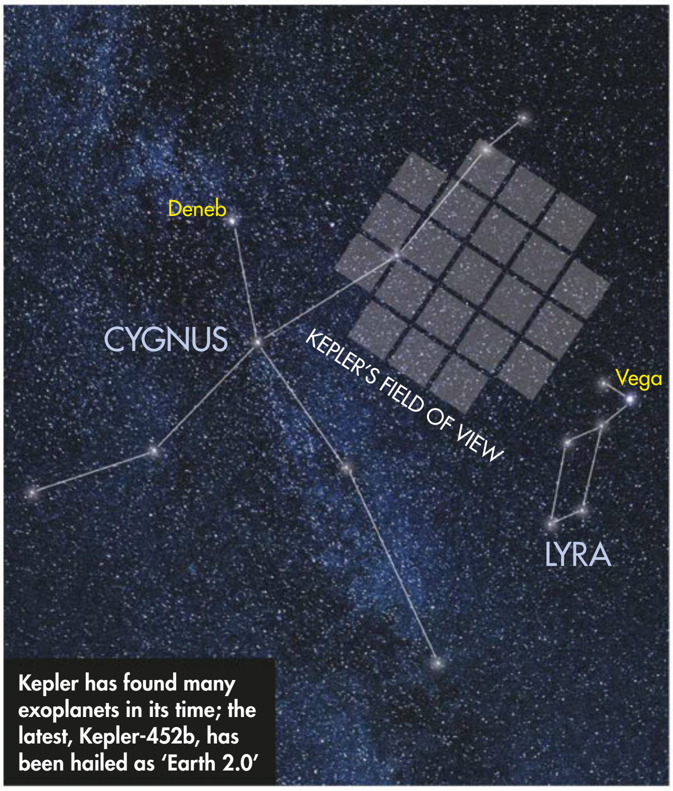
THOMAS HENNE/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT, JOHANNES SCHEDLER/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT, WILL GATER, ISTOCK

5. Kepler's first field of view

The science: A patch of sky that's home to hundreds of exoplanets.
Where is it? At the intersection of the constellations of Cygnus, Lyra and Draco.

One of the great joys of observing Cygnus is scanning the rich star fields scattered across the constellation with a good pair of binoculars. Seeing myriad sparkling points of light scattered against the black can be a profound experience, and if you're like us you'll no doubt have wondered if – in all of those thousands of star systems – there is anyone looking back towards Earth.

While we don't yet know if there's life out there in the Galaxy, what we do know is that one patch of sky in the constellation is teeming with exoplanets – worlds around other stars. We know this because Cygnus, and its neighbouring constellations Lyra and Draco, was home to the first field of view of NASA's Kepler space telescope. It was launched in March of 2009 and was designed to seek out Earth-like exoplanets orbiting around stars in this region. It does this by looking for slight reductions in the light from certain stars that are created when a planet 'transits' in front of a blazing stellar disc. The mission has been a great success and to date it has found over 1,000 alien worlds, including many that have similarities with rocky planets like Earth.



Kepler has found many exoplanets in its time; the latest, Kepler-452b, has been hailed as 'Earth 2.0'


Though it has the guise of a supernova remnant, the star that spawned this gas cloud is still alive

6. The Crescent Nebula

The science: An enormous glowing cloud of gas associated with a Wolf-Rayet star.
Where is it? At the heart of Cygnus, just over one-third of the way along a line between the Sadr (Gamma Cygni) and Eta Cygni.

The Crescent Nebula, NGC 6888, is a faint, glowing oval of a gas lying near the centre of Cygnus. It is one of the Swan's most popular targets for astro imagers – but it also happens to be one of the most scientifically interesting.

Long-exposure images taken with sensitive CCD cameras reveal the nebula to have intricate sponge-like appearance. At first glance you could be forgiven for thinking that what you're seeing is a supernova remnant, like the Veil Nebula Complex. In fact the Crescent Nebula was formed, not in the moment of stellar death, but by a behemoth approaching its deathbed. At the heart of the nebula is a Wolf-Rayet star known as WR 136. Long ago, this massive star was an ageing red supergiant, ejecting vast amounts of dust and gas into its surroundings. Now, however – after its evolution into a Wolf-Rayet star – an intense stellar wind roars from WR 136, while ultraviolet radiation from the star causes the scattered gas around it to glow.

In time it's thought that WR 136 will explode in spectacular fashion, creating a supernova and eventually forming another supernova remnant among the sparkling star fields of Cygnus.

7. The Cocoon Nebula

The science: A spectacular, glowing gas cloud that's home to numerous newly formed and embryonic stars.
Where is it? Beyond the tail of Cygnus, between the bright star Deneb (Alpha Cygni) and the stars of Lacerta.

While a few of the objects we've covered here relate to the science of stellar death, Cygnus is also home to regions of dramatic star birth too. There's the famous North America Nebula, or NGC 7000, which is not far from mag. +1.3 Deneb (Alpha Cygni), as well as the huge expanse of glowing nebulosity around mag. +2.2 Sadr (Gamma Cygni), which is peppered with stellar nurseries.

Frenetic stellar creation is also evident in the many open clusters of stars that can be found littering Cygnus. But of all these star-formation sites, the Cocoon Nebula, or IC 5146, surely has to be the most intriguing. To really get a sense of the extent of this exquisite object you have to look at a long-exposure image of the region. The main part of the nebula consists of a striking cloud of hydrogen gas being excited by the radiation of a young star embedded within it. Astro images of the surroundings and, most notably, professional data from infrared space telescopes also reveal another feature of this object however: an enormous, dark, dust and gas cloud trailing away from the nebula where stars are only just beginning to materialise.


The Cocoon Nebula is expansive, spread across 15 lightyears

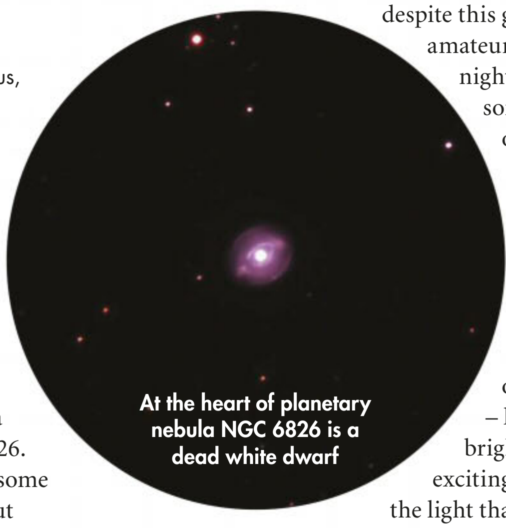
8. NGC 6826

The science: A glowing planetary nebula, the remnant of a long-dead Sun-like star.
Where is it? In the northern 'wing' of Cygnus, just over 10° along a line between Deneb (Alpha Cygni) and Iota Cygni.

Our journey around some of the scientific wonders of Cygnus draws to a close in a patch of sky no more than a fist's width at arm's length from mag. +1.3 Deneb (Alpha Cygni). Here, away from the main swathe of dense star fields that run through the constellation, sits a tiny celestial gem – a planetary nebula catalogued as NGC 6826.

The faint glow from NGC 6826 takes some 2,200 years to reach us here on Earth, but despite this great distance it's still visible to amateur-sized telescopes on clear autumn nights. The nebula is both a vestige of something passed and an insight into our own star's future. It was created by the slow death of a star similar to our Sun. As it aged, the star shed its atmosphere into the cosmos, forming enormous clouds of dust and gas around its faltering body.

In time the hot core of the star became exposed as the star ejected its outer layers and it is this blazing heart – known as a white dwarf – that shines brightly at ultraviolet wavelengths today, exciting the gas surrounding it and so creating the light that we see from the nebula.


At the heart of planetary nebula NGC 6826 is a dead white dwarf

ISTOCK, MANFRED WASSHUBER/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT, HANNES BACHLEITNER/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT, FRANZ KLAUSER/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT

Sketching the Moon

▲ Dierdre's sketching setup; an easel is a great help, both for drawing and holding pastels

Deirdre Kelleghan explains how to capture the intricacies of the lunar surface on black paper using just pastels and Conté crayons

The Moon's majesty is clear to see with the naked eye, but when viewed through a telescope it becomes even more magnificent – the range of shapes, structures and shadows waiting to be observed is intricately beautiful. But don't let the complexity of the lunar surface put you off sketching it. If you feel overwhelmed, try sketching the full Moon, when there are fewer shadows, in a drawing with a small diameter – say the size of a CD rather than a dinner plate. Start your journey by concentrating on just a few features.

One of the challenges of drawing the Moon in the lighter months is the shorter hours of darkness. It is possible to overcome this, however, by making use of the long periods of twilight.

It is also worth setting up your telescope and equipment the day before to maximise the time you have to spend actually drawing. When planning, make sure you position your setup so that you have a clear line of sight to the Moon – you don't want to find it obscured by trees or buildings in the middle of your sketch. You can use smartphone apps such as Starmap Pro (iOS only) to determine the best position for your telescope in relation to the rising Moon. Computer software such as the freeware Stellarium (**www.stellarium.org**) can also be useful.

You should use an eyepiece that fits the entire Moon comfortably into the field of view, rather than filling it, as this will prevent the Moon from moving out of view too quickly. This is particularly helpful if your telescope does not have a motor drive. For my sketch of the last quarter Moon, shown opposite, I used an 8-inch Dobsonian with a 1,200mm focal length and a 32mm eyepiece, giving a magnification of 37x.

The clock is ticking...

When attempting to not only sketch vast areas of the lunar surface, but do so in high contrast, every second of darkness counts. The best contrast for sketching is along the terminator, the line dividing light and dark on the lunar surface. Note that the terminator is far from straight through a telescope. Whether the Moon is waxing or waning, its lit and shadowed structures give great form to a sketch.

When you are drawing, avoid concentrating solely on one specific point and try to pay equal attention to the various structures. This way, if cloud interferes and obscures the field of view, you may still have something satisfying to show, even if it is unfinished. It is worth drawing in features even if you don't know their names, as you can identify them later using software such as the Virtual Moon Atlas (**www.ap-i.net/avl/en/start**).

It's a good idea to be aware of the entire target when adding new features. Placing a finger on a crater in the sketch and then looking in the telescope will help guide you to the next crater location. Don't worry ▸

Equipment

Mounted telescope, field easel, soft pastels, Conté crayons, black paper, quilling needle

DEIRDRE KELLEGHAN X 3, ISTOCK

Deirdre's lunar sketch of the last quarter Moon was completed in Bray, County Wicklow, Ireland

▸ if you haven't quite captured a specific shape, as soft pastels are very forgiving, enabling you to wipe out entire areas with your fingers and start again. A quilling needle is also a boon – you can use it as an etching tool for introducing lines or removing unnecessary marks in craters.

I find a caving headlight useful as it has two beams that are independent of each other. The LED can shine on your sketch, but is easily pushed out of the way when viewing through the telescope, while the main beam is handy for viewing the whole sketch as it progresses and there is no need for a red light. In its fuller phases, the Moon can even be bright enough to illuminate the sketch for you.

A field easel is a gift for outdoor sketching, as you can adjust the angle of the drawing surface, its drawer can hold your art materials and the legs can be set at varying heights.

During my sketching period I was lucky to have the dramatic structure of the Montes Appeninus slowly giving in to the encroaching blackness of lunar night. The Sun's receding rays glinted off the rugged range, adding to the richness of the target. One tip is to look out for Crater Tycho's ejecta rays, arcing toward Crater Kepler – they are always helpful for bringing curvature to a lunar drawing.

...but keep an eye on it

Due to the concentration required while drawing, I only became aware of the dawn when the albedo features on the Moon started to increase. Tiny circular craters were suddenly illuminated around their rims, and more and more highlights appeared close to Crater Plato and the Sinus Iridum. The time had come to end the sketch as the contrast was bowing out to the subtle blues of the daytime Moon. A decision had to be made: would I finish it in blue or black? For me it had to be the latter as the terminator was still showing black and, of course, the origin of the sketch was in the dark skies of the night.

Once finished I applied a matt varnish spray, a useful fixer for the sketch. After that there was just one more thing to be done; noting down the start and end time of the sketch in UT. This will enable me to compare the sketch with images taken by others over the same period. Ⓢ

ABOUT THE WRITER

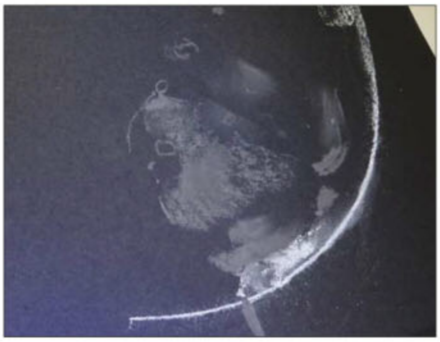
Deirdre Kelleghan is an artist, astronomer and co-author of *Sketching the Moon: An Astronomical Artist's Guide.*

Step by step

How to make the most of your lunar sketching time

STEP 1

Always try to maximise your time by targeting the rising Moon. Use a dinner plate to outline the limb with white Conté crayon. If your sketching window is short, make the outline using a side plate or CD.



STEP 2

Observe the lunar surface. Use a dark grey pastel to add approximate shapes for the lunar maria and a white pastel for the highlands. Accurately position light marks for at least three craters in different areas.

STEP 3

Use your black pastel to begin drawing the shapes you observe along the terminator; the corners of the pastel are good for this. When crater rims break the blackness, use a white Conté crayon to edge the shape.

STEP 4

Balance the drawing by switching between the terminator, craters and maria as you go. Keep every new feature you add related to your three craters from Step 2. Build up the drawing by adding detail to the three original features.

STEP 5

Use your fingers to spread pastel on the maria, then overlay major craters like Copernicus in a paler grey. Use a white Conté crayon to add any central mountains and a black Conté crayon to edge the craters.

STEP 6

You can finish the sketch by using a black pastel on its side to edge the limb. Then blacken the rest of the page. It can be useful to take an image of your drawing before fixing it too much, to avoid the potential loss of fine detail.

DEIRDRE KELLEGHAN X 6, ISTOCK

PLUS

Stephen Tonkin's

BINOCULAR TOUR

Turn to page 58 for six of this month's best binocular sights

The Sky Guide September

This month's full Moon on 28 September is a perigee Moon, the nearest, largest and brightest of the year. As it's also the closest full Moon to the autumn equinox, this is also the Harvest Moon. Just to top it all off, it coincides with a stunning total lunar eclipse.

PETE LAWRENCE

Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

Highlights

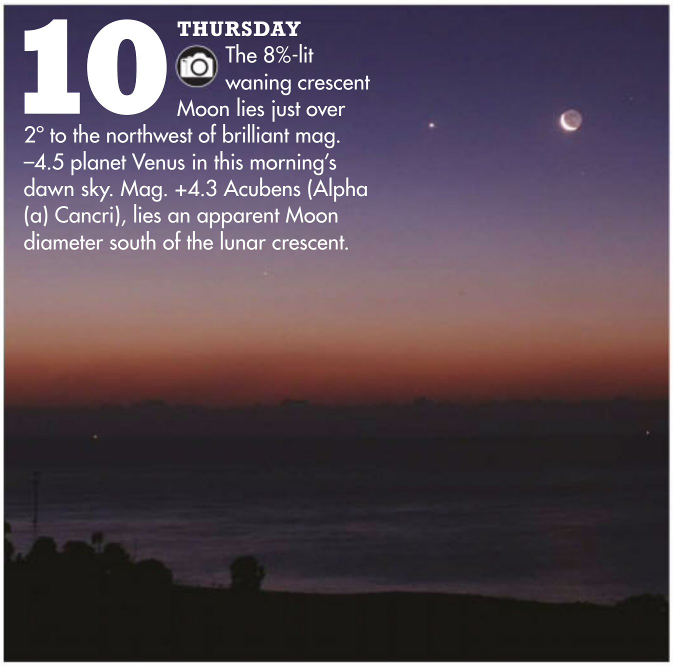
Your guide to the night sky this month

This icon indicates a good photo opportunity

1 TUESDAY
Neptune, the Solar System's most distant planet, reaches opposition today. It's in the watery constellation of Aquarius, the Water Bearer, below the asterism known as the Water Jar. Neptune is too faint for the naked eye alone; you'll need a pair of binoculars at least to see it.

2 WEDNESDAY
Look for mag. +3.6 Kappa (κ) Geminorum low in the east-northeast around 03:30 BST (02:30 UT): 2° southeast of it is the faint comet 141P/Machholz. Located midway between the two is Rosetta's comet, 67P/Churyumov-Gerasimenko. See page 51.

5 SATURDAY ▶
The Moon will occult mag. +0.9 Aldebaran (Alpha (α) Tauri) this morning. Watch the event from 05:30 to 07:10 BST (04:30 to 06:10 UT). Disappearance occurs at the Moon's bright limb but reappearance is trickier, occurring from behind the dark limb in a bright daylight sky. See page 51.



10 THURSDAY
The 8%-lit waning crescent Moon lies just over 2° to the northwest of brilliant mag. –4.5 planet Venus in this morning's dawn sky. Mag. +4.3 Acubens (Alpha (α) Cancri), lies an apparent Moon diameter south of the lunar crescent.

11 FRIDAY
Mars forms a triangle with mag. +1.4 Regulus (Alpha (α) Leonis) and a thin waning crescent Moon (3% lit) in the dawn twilight. Look for them from 05:00 BST (04:00 UT), low in the eastern part of the sky.

12 SATURDAY
The very thin waning crescent Moon (now only 1% lit) is 3.75° south of Jupiter in the morning sky. Look from 05:50 BST (04:50 UT), low in the east. The brightening twilight will disguise the Moon somewhat; its slender crescent will be below and right of Jupiter.

14 MONDAY
Dim comet 141P/Machholz lies a little over 2° south of the Beehive Cluster, M44 in cancer. M44 is low in the east-northeast before dawn starts to break at around 04:00 BST (03:00 UT). See page 51.

16 WEDNESDAY ▶
The familiar W shape of Cassiopeia is virtually overhead during the early hours, giving a great opportunity to view some of the amazing objects that lurk within its borders. These include the Owl Cluster, designated NGC 457, and the Pacman Nebula, or NGC 281.

18 FRIDAY ▶
The 25%-lit waxing crescent Moon is 4.5° northwest of Saturn this evening – the pair will be low in the southwest at around 20:45 BST (19:45 UT). Saturn is rather altitude challenged, but if you can get a look at it through a telescope, you'll see that its rings are nicely open at present.

23 WEDNESDAY ▶
The northern hemisphere autumn equinox occurs at 09:21 BST (08:21 UT). This is the exact moment in time when the centre of the Sun's disc crosses the celestial equator. It also represents the time when the rate of change of solar declination with time is at its greatest for the year.

24 THURSDAY
The bright star approximately 7° up and due south at midnight is mag. +1.2 Fomalhaut (Alpha (α) Piscis Austrinus). This is the most southerly first-magnitude star visible from the UK.

25 FRIDAY ▶
Mars and mag. +1.4 Regulus (Alpha (α) Leonis) are just 47 arcminutes apart in the morning sky. Look out from around 04:30 BST (03:30 UT), when they will be low in the eastern part of the sky; Mars will be north of the star. This is a great chance to compare and contrast their colours.

28 MONDAY ▶
There's a triple lunar event with this morning's full Moon. Being the closest to the equinox makes this the Harvest Moon; it's also the largest full Moon of the year; and, most excitingly of all, it is totally eclipsed by Earth's shadow. See page 50.

PETE LAWRENCE X 8

8 **TUESDAY**
The small constellation of Delphinus, the Dolphin, is just over halfway up the sky due south at around 22:30 BST (21:30 UT). It is sometimes mistaken for the Pleiades open cluster by virtue of its shape.

9 **WEDNESDAY**
With the Moon now largely out of the way this is a great time to attempt our deep sky and binocular tours – see pages 56 and 58.

13 **SUNDAY ▶**
Look two-thirds of the way up the sky, just east of south, around midnight. The pattern on show here is the Great Square of Pegasus asterism. The constellation of Andromeda extends from mag. +2.1 Alpheratz (Alpha (α) Andromedae), the northeastern star in the square.

29 **TUESDAY**
The 98%-lit waning gibbous Moon lies just over 1.5° south of Uranus at 03:00 BST (02:00 UT) this morning.

What the team will be observing in September

Pete Lawrence "There's lots happening this month but I'm going to try for the 'Rosetta comet', 67P/Churyumov-Gerasimenko, with my own telescope. The comet's low altitude will be a challenge, but that makes it fun to try!"

Steve Marsh "I love the crescent phase of Venus at the moment. It's always a challenge to take a sharp photograph of such a typically low object, but its size and position is perfect for imaging this month."

Chris Bramley "The 28th will start very early for me, as I want to watch the full drama of the total lunar eclipse. I can't wait to see what colour the Moon will be."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

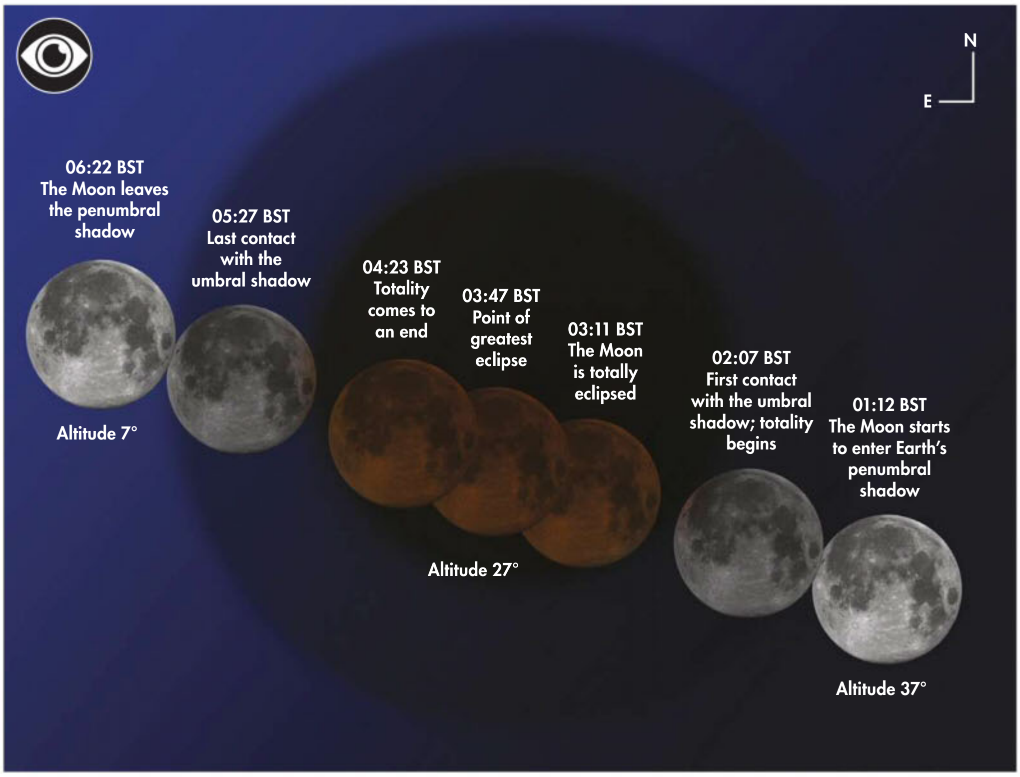
DON'T MISS... 3 top sights

A total eclipse of the Moon

WHEN: 28 September, 02:07 to 05:27 BST (01:07 to 04:27 UT)

NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.



The most dramatic changes will be seen as the Moon passes into Earth's umbral shadow after 02:07 BST

UNLIKE ITS SOLAR counterpart, a total eclipse of the Moon is a relaxed affair. Lunar totality typically takes over an hour to complete, so there's plenty of time to enjoy the show. If you count the partial phases as well, the eclipse takes even longer to play out. For the lunar eclipse that's due to occur on 28 September, the full show lasts for three hours and 20 minutes.

This can be extended further still if you're prepared to 'watch' the weak penumbral phase of the eclipse. This is when the Moon passes through the lighter outer part of Earth's shadow. Barely noticeable to the naked eye, the penumbral phase is best recorded with a camera. Taking this into account in terms of event duration, this month's eclipse lasts around five hours and 10 minutes!

The penumbral phase starts at 01:12 BST (00:12 UT) on the 28th, but don't expect to see much at this time. The Moon will be roughly due south and 37° up as seen from the centre of the UK at this point.

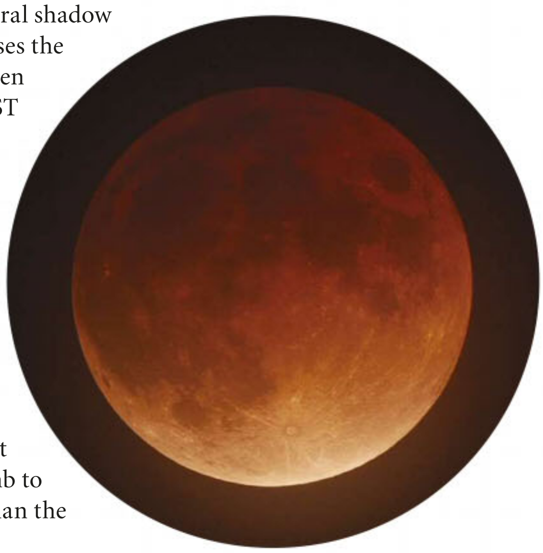
First umbral contact occurs almost an hour later at 02:07 BST (01:07 UT). In the period leading up to this time, the western part of the Moon's disc should start to appear subtly shaded darker than normal. The edge of the umbra is blurred rather than sharp, and at this point you will see this fuzzy shadow edge starting to make its mark.

The dark umbral shadow then slowly crosses the lunar disc between 02:07 to 03:11 BST (01:07 to 02:11 UT), at which time totality is reached. The Moon is passing though the southern portion of the umbral shadow during this eclipse, so expect the southern limb to appear lighter than the northern one.

At greatest eclipse, the northern limb virtually marks the centre of the umbral shadow. Greatest eclipse occurs at 03:47 BST (02:47 UT) when the Moon's in the southwest, 27° up.

Totality officially ends at 04:23 BST (03:23 UT) when the Moon reaches the southeast edge of the umbral shadow. After this, the second partial phase of the eclipse begins and lasts until 05:27 BST (04:27 UT), when the Moon officially leaves the umbral shadow, bringing the event to an end. The Moon's altitude will be 15° at this time and dawn will have begun.

This is a perigee-syzygy Moon, meaning that it is a full Moon occurring at the closest point in the lunar orbit to Earth. Consequently, it's the largest full Moon of the year with an apparent diameter of nearly 33.5 arcminutes. It's also the closest full Moon to the northern hemisphere's autumn equinox, making it the 2015 Harvest Moon.

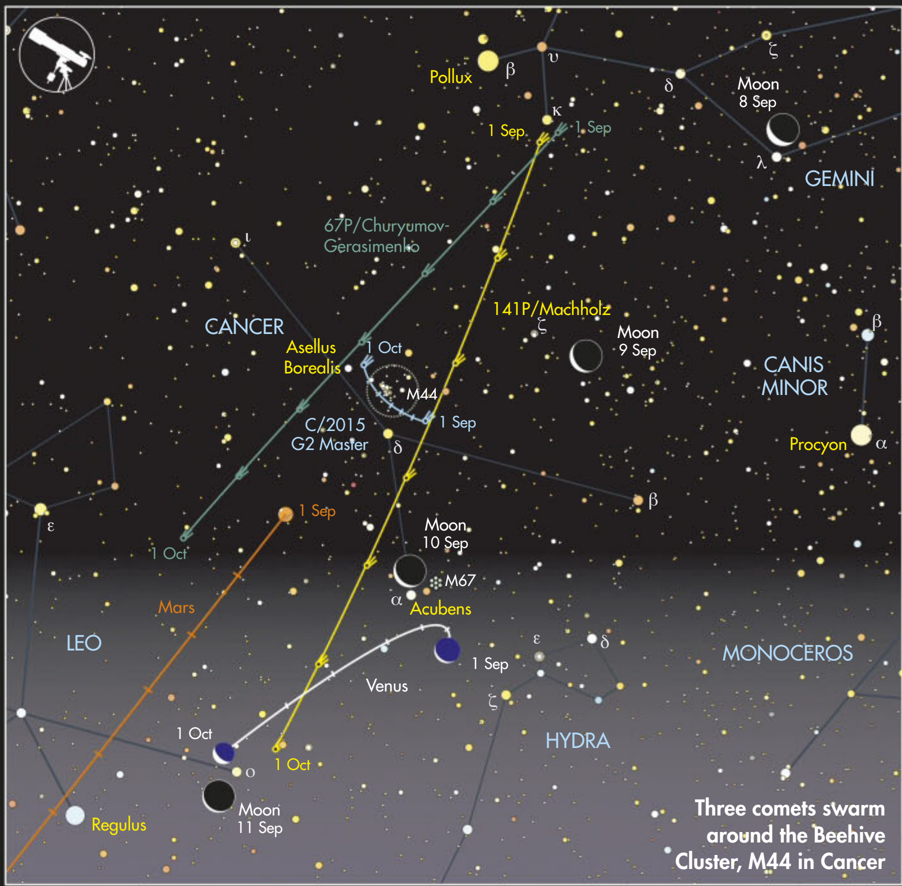


▲ **During a lunar eclipse our neighbour can gain a ruddy hue**

PETE LAWRENCE X4

Comets 141P/Machholz and 67P/Churyumov-Gerasimenko

WHEN: See chart; there is less Moon interference in the middle of the month



Three comets swarm around the Beehive Cluster, M44 in Cancer

COMET 141P/MACHHOLZ will rise in the east-northeast part of the sky at the start of the month, and it attains a respectable altitude of nearly 20° before the dawn twilight begins around 04:00 BST (03:00 UT). The comet starts the month in Gemini, close to mag. +3.6 Kappa (κ) Geminorum. It has been performing badly of late and could be around 15th-magnitude. This is dim even for a large telescope. A much better prospect is the Rosetta comet, 67P/Churyumov-Gerasimenko. At the start of September this should be around mag. +13.3. Again this will require a telescope to see but it should be a fairly easy target for imagers.

On 1 September, the two comets and Kappa Geminorum form an almost right-angled triangle, with 67P at the right angle. If you can identify Kappa Geminorum and 141P/Machholz on the morning of the 2nd, you'll find that 67P is conveniently midway between them. Both comets fade through the rest of the month. By the 14th, 141P may be around mag. +16.0 and around 1.5° south of the Beehive Cluster, M44 in Cancer. 67P should be brighter at around mag. +13.4 and a little further away, 4° northwest of M44.

The 14th-magnitude comet C/2015 G2 Master will also be 'buzzing' the Beehive during this period, passing up in front of the eastern edge of the cluster. On the 17th, 67P sits 0.3° north of mag. +4.7 Asellus Borealis (Gamma (γ) Cancri) . The Moon interferes at the start and end of September, so this alignment may present the better opportunity to spot the historic comet.

The lunar occultation of Aldebaran

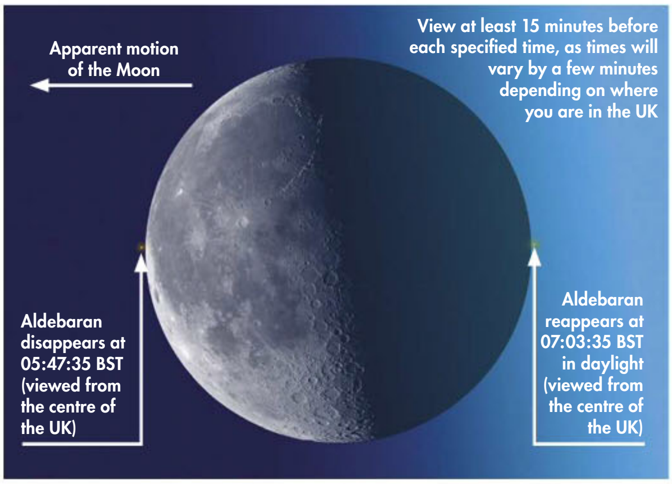
WHEN: 5 September, 05:30 to 07:10 BST (04:30 to 06:10 UT)

THE MOON HAS been making close passes of the bright star Aldebaran (Alpha (α) Tauri) for a few months now, but on the morning of 5 September, the two will finally meet – kind of. While in reality Aldebaran will be around 1.4 billion times farther away, from our perspective the Moon's edge will at least appear to pass in front of the star.

Like all stars, Aldebaran is so distant that it looks like a point source of light. The Moon has no atmosphere, so when its edge covers the star, Aldebaran will disappear instantly.

This month's encounter is the first of several in the coming months. From the centre of the UK, the last quarter Moon's leading bright edge covers the star at 05:47 BST (04:47 UT), as the dawn twilight is lightening the sky.

Even so, given clear conditions, the event should be fairly easy to see with any instrument. For something more challenging, try to spot the star's reappearance, after sunrise, at around 07:03 BST (06:03 UT). To achieve this, it will be necessary to estimate the location of the dark edge of the Moon just before the star is due to reappear. Even in daylight, the bright dot of Aldebaran should still be visible.



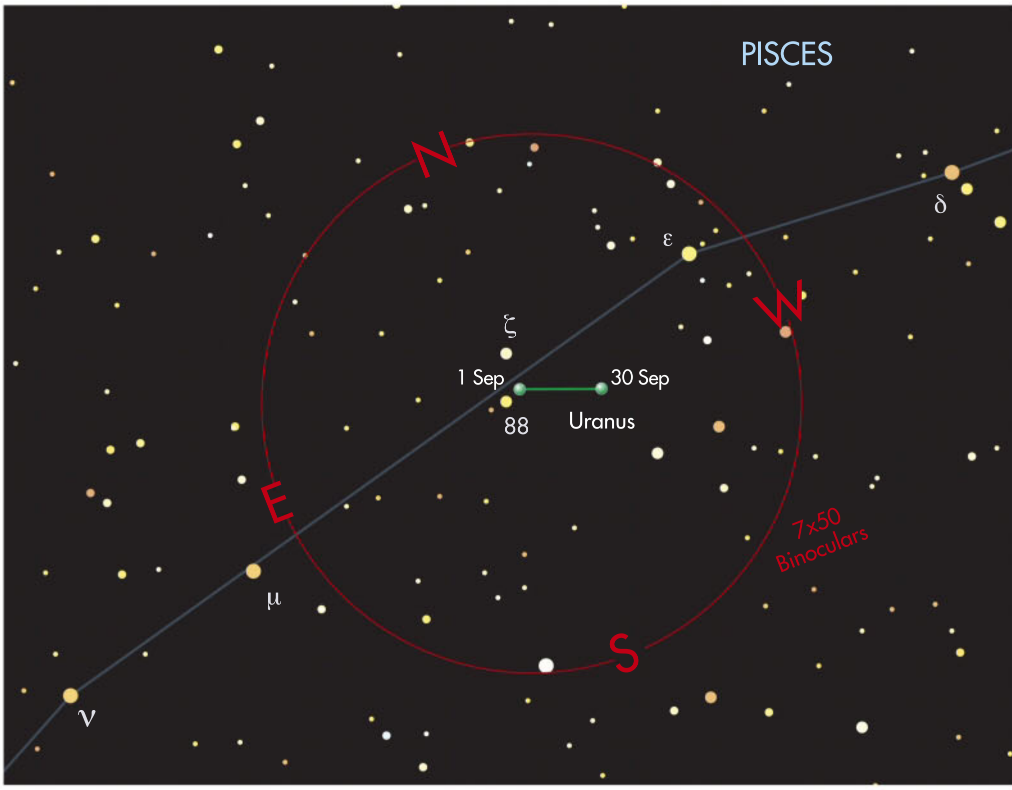
Reappearance will be harder to see as the sky brightens during the event

The planets

PICK OF THE MONTH

URANUS

BEST TIME TO SEE: 30 September 02:00 BST (01:00 UT)
ALTITUDE: 44°
LOCATION: Pisces
DIRECTION: South
FEATURES: Colour, banding and moons visible in larger scopes
EQUIPMENT: Small telescope for colour, 8-inch or larger for disc detail if present

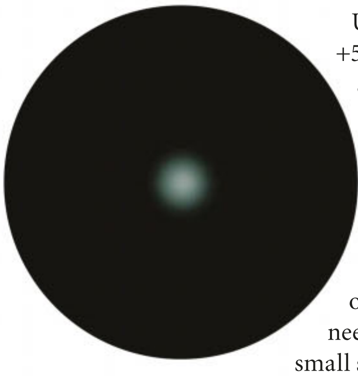


Uranus creeps west from Zeta Piscium, but at a slow pace – it is still in the vicinity at month end

URANUS IS THE second most distant planet in the Solar System, the outer position being held by Neptune. Through a telescope Uranus shows a definite disc, but it can look a little bland and featureless. This is down to a number of factors. Distance plays its part of course, but the planet's weather is also a contributing factor. Normally, Uranus shows little in the way of features other than slightly lighter regions around the poles. These translate as bands, which can sometimes be seen through larger scopes. However, in 2014, Uranus surprised everyone by exhibiting bright storms that were imaged by amateurs on Earth.

The planet's apparent size is around 3.7 arcseconds, which means that it appears larger than the moons of Jupiter; it is for instance more than twice the apparent size of Ganymede. Imagers are now regularly capturing surface detail on Ganymede, so Uranus is a viable target too, albeit a slightly dimmer one than the giant moon.

Uranus starts the month 0.5° south of Zeta (ζ) Piscium and 13 arcminutes west of the mag. +6.0 star 88 Piscium. As September rolls on, the planet will move farther to the west, ending up more than 1° west and slightly south of 88 Piscium by month end.



You need a telescope to reveal the planet's hue

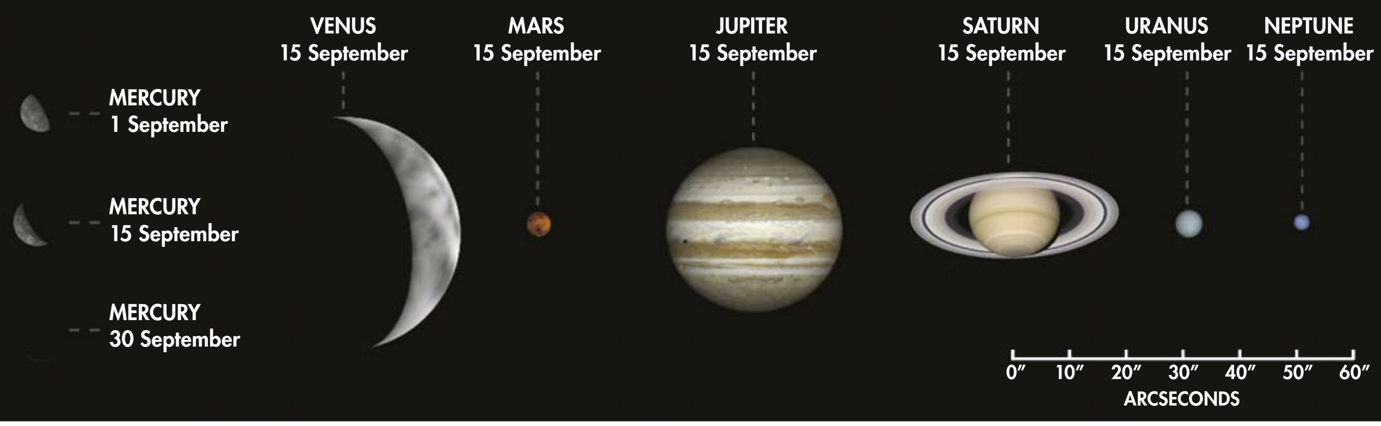
Uranus remains at mag. +5.7 throughout the month, so it is theoretically visible to the naked eye. This can be tricky to achieve unless your sky is good and dark. Binoculars are a safer bet, but to experience the green hue of the planet's disc you'll need a telescope. Even a small scope will show its colour.

On 12 September, Uranus forms a small isosceles triangle with Zeta and 88 Piscium, Zeta Piscium marking the top of the shape, Uranus the bottom right.

PETE LAWRENCE X 3

THE PLANETS IN SEPTEMBER

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



VENUS
BEST TIME TO SEE:
30 September
06:30 BST (05:30 UT)
ALTITUDE: 28°
LOCATION: Leo
DIRECTION: East-southeast

Venus is a morning object rising 96 minutes before the Sun at the start of September but an impressive four hours before the Sun at the end of the month. This is due to two factors: Venus's increasing apparent distance from the Sun and the steep angle the ecliptic makes with the eastern horizon in the pre-dawn sky at this time of year.

On the 1st, a telescope will reveal Venus as an impressive 52-arcsecond, 9%-lit crescent. As the planet moves around its orbit, its apparent distance from the Sun increases and its phase decreases. At month end, it will appear 33 arcseconds across and 35% lit. Venus remains at mag. –4.5 throughout.

NEPTUNE
BEST TIME TO SEE:
1 September 01:00 BST (00:00 UT)
ALTITUDE: 28°
LOCATION: Aquarius
DIRECTION: South

Neptune comes to opposition, when it is opposite the Sun in the sky, on the 1st. At mag. +7.8, Neptune is the only major planet that can't be seen with the naked eye, although Uranus can be a challenge too. It is in Aquarius, 3° southwest of mag. +3.7 Lambda (λ) Aquarii.

Neptune presents a tiny disc through a scope, 2.3 arcseconds across. A bright storm was seen on the planet recently and has been imaged by amateurs using 12-inch or larger telescopes. At opposition on the 1st, Neptune is optimally placed, and visible throughout the night.

MARS
BEST TIME TO SEE:
30 September
06:00 BST (05:00 UT)
ALTITUDE: 19°
LOCATION: Leo
DIRECTION: East

Mars is a morning object, close to mag. +1.4 Regulus (Alpha (α) Leonis). On 25 September, orange-hued Mars will be just 47 arcminutes from this blue star. Such encounters provide a lovely opportunity to compare and contrast the colours of both objects – a photograph will also show the colours off nicely. Telescopically, Mars is a bit puny at the moment as it is a long way away from Earth. Its apparent diameter is just 3.8 arcseconds for much of the month, which is about the same apparent size as Uranus. At mag. +1.8, it is not particularly bright either. The Red Planet rises three hours and 18 minutes before the Sun at the end of the month, but fails to reach its highest point, due south, in darkness.

JUPITER
BEST TIME TO SEE:
30 September
06:00 BST (05:00 UT)
ALTITUDE: 18°
LOCATION: Leo
DIRECTION: East

Jupiter is slowly but surely reappearing in the morning sky. It's pretty low in the northeast before sunrise at the start of September, but its situation improves throughout the month. At mag. –1.7, Jupiter is bright but still easily outshone by nearby Venus.

SATURN
BEST TIME TO SEE:
1 September
21:00 BST (20:00 UT)
ALTITUDE: 11°
LOCATION: Libra
DIRECTION: Southwest

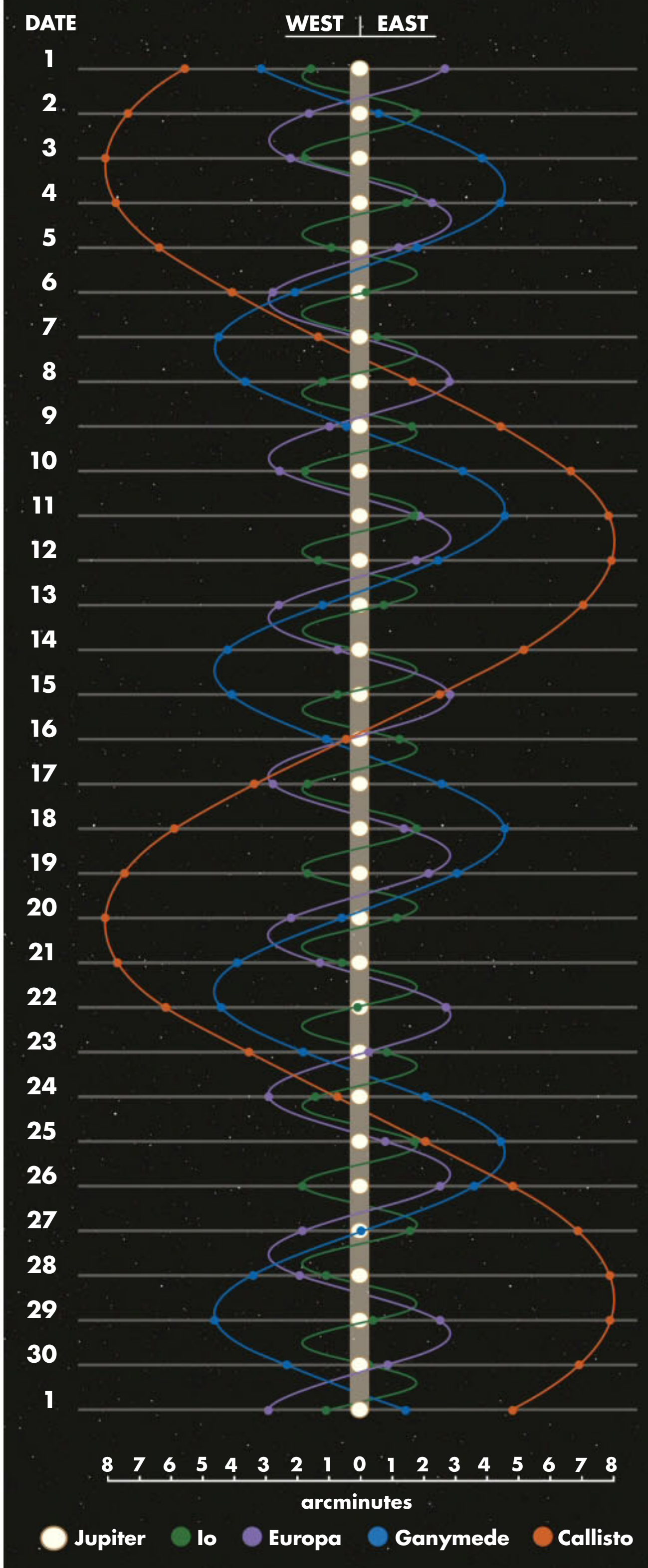
Saturn is severely altitude challenged, but its mag. +0.6 dot should be visible low in the southwest as the sky darkens throughout the month.

NOT VISIBLE THIS MONTH
MERCURY

See what the planets look like through your telescope with the **field of view calculator** on our website at:
http://www.skyatnightmagazine.com/astronomy-tools

JUPITER'S MOONS
September

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

- *Arcturus* — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

COMPASS AND FIELD OF VIEW

MILKY WAY

WHEN TO USE THIS CHART

1 SEPTEMBER AT 01:00 BST
15 SEPTEMBER AT 00:00 BST
30 SEPTEMBER AT 23:00 BST

On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

THE SUN IN SEPTEMBER*

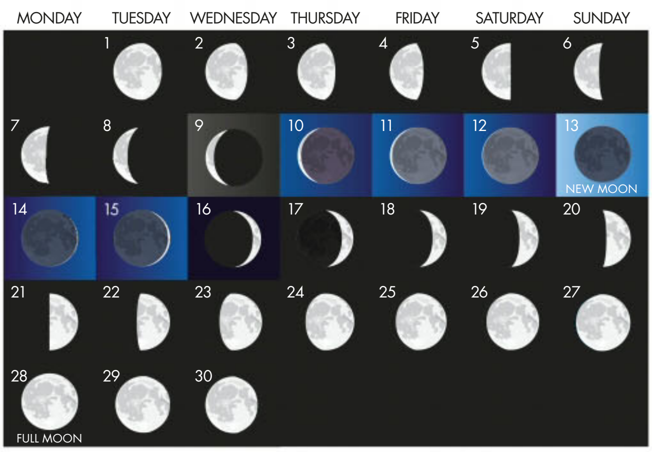
DATE	SUNRISE	SUNSET
1 Sep 2015	06:18 BST	20:00 BST
11 Sep 2015	06:35 BST	19:36 BST
21 Sep 2015	06:53 BST	19:12 BST
1 Oct 2015	07:10 BST	18:47 BST

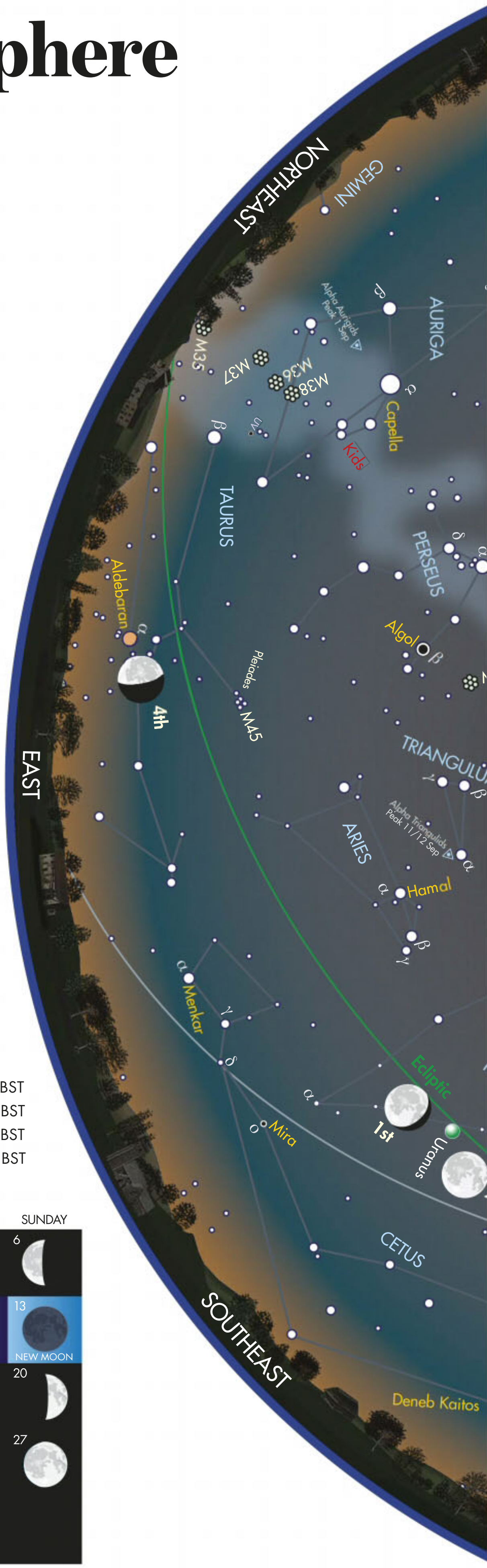
THE MOON IN SEPTEMBER*

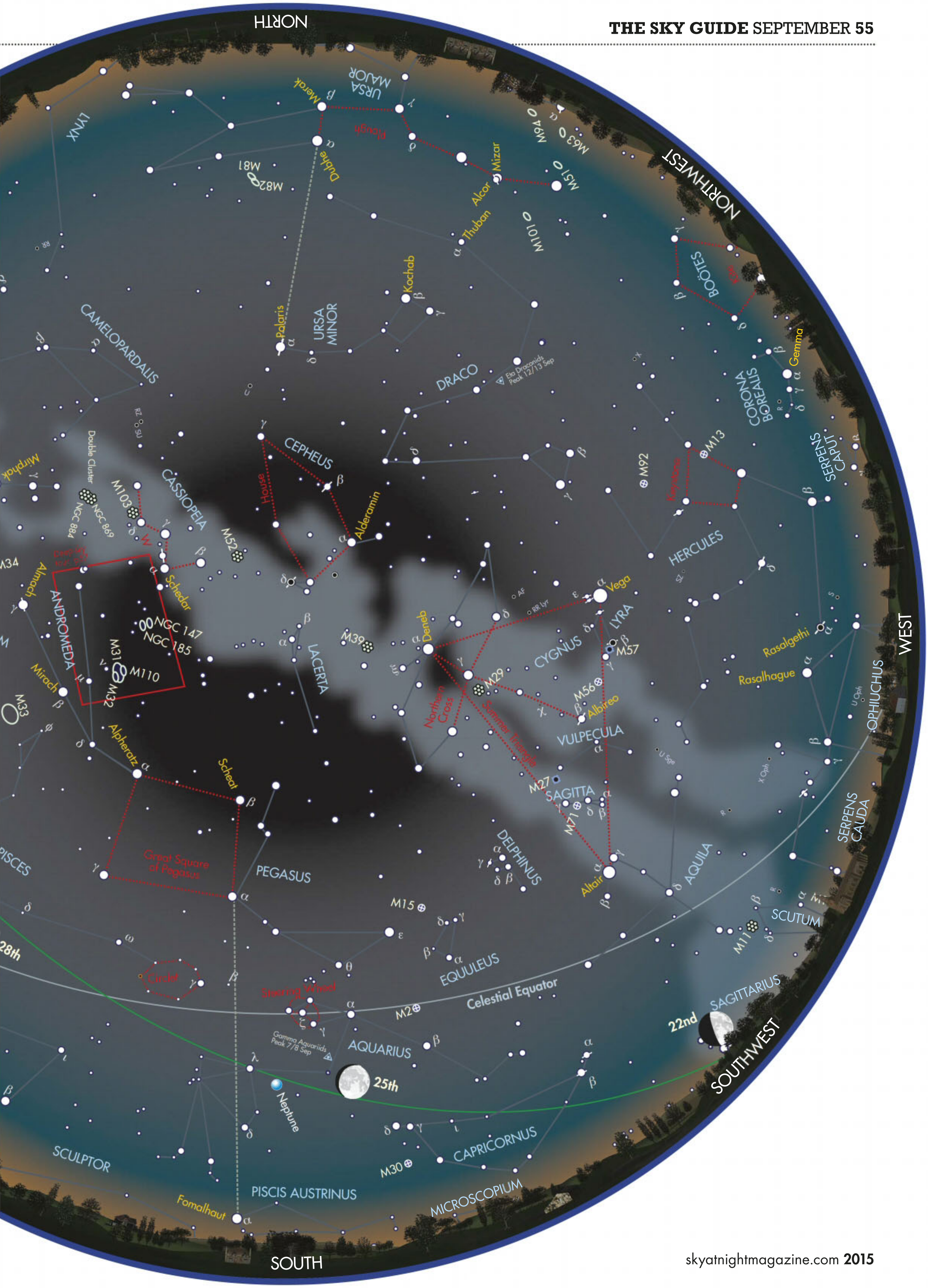
MOONRISE TIMES

1 Sep 2015, 21:16 BST	17 Sep 2015, 11:00 BST
5 Sep 2015, 23:45 BST	21 Sep 2015, 14:58 BST
9 Sep 2015, 02:32 BST	25 Sep 2015, 17:43 BST
13 Sep 2015, 06:46 BST	29 Sep 2015, 19:43 BST

*Times correct for the centre of the UK






NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LYNX
URSA MAJOR
Merak
Dubhe
Plough
M81
M82
M94
M63
M51
Mizar
Alcor
Thuban
M101
Kochab
URSA MINOR
Polaris
CAMELOPARDALIS
DRACO
Eta Draconids Peak 12/13 Sep
BOÖTES
Izar
CORONA BOREALIS
Gemma
SERPENS CAPUT
M13
Keystone
M92
HERCULES
CEPHEUS
House
Alderamin
CASSIOPEIA
Double Cluster
NGC 884
NGC 869
M103
W
M52
Schedar
Mirphak
M34
Almach
ANDROMEDA
NGC 147
NGC 185
M31
M110
M32
Mirach
M33
LACERTA
M39
Deneb
CYGNUS
Vega
LYRA
M57
M29
M56
Albireo
Northern Cross
Summer Triangle
VULPECULA
Rasalgethi
Rasalhague
OPHIUCHUS
M27
SAGITTA
M71
DELPHINUS
Altair
AQUILA
SERPENS CAUDA
SCUTUM
M11
Alpheratz
Scheat
PISCES
Great Square of Pegasus
PEGASUS
M15
EQUULEUS
28th
Circlet
Steering Wheel
Celestial Equator
M2
AQUARIUS
Gamma Aquariids Peak 7/8 Sep
SAGITTARIUS
22nd
25th
Neptune
CAPRICORNUS
M30
SCULPTOR
PISCIS AUSTRINUS
MICROSCOPIUM
Fomalhaut

Deep-sky tour

Join us as we explore the satellies of M31, the closest large galaxy to our own

☑ Tick the box when you've seen each one

To end our galaxy quest we have a very different target: M76, the faintest planetary nebula in Messier's catalogue

1 THE ANDROMEDA GALAXY

The magnificent Andromeda Galaxy, M31, is a treat in any instrument. A 6-inch scope at low magnification shows it as a 120x20-arcminute oval smudge with a brighter 10-arcminute core. A dark dust lane defines the northwest edge of the oval. In a 10-inch scope, the lane is distinct close to the core and can be followed some distance northeast and southwest. The faint outer spiral arms appear patchy in larger scopes. A large star cloud, NGC 206, can be seen in one of the arms to the southwest of the core. M31 is the nearest large galaxy to the Milky Way, at a distance of 2.5 million lightyears. ☐ **SEEN IT**

2 M32

A number of smaller satellite galaxies are gravitationally bound to the Andromeda Galaxy. One of these is elliptical galaxy M32, which sits 22 arcminutes south of M31's core – actually within M31's boundary. Visually it's not obvious whether M32 is in front of or behind M31, but spectroscopic analysis suggests that it is in front. M32 is quite bright at mag. +8.2 and an easy spot though a small scope, appearing as an overinflated star at low magnification. Under high magnification it looks a bit ragged around the edge. The galaxy brightens rapidly from its outer edge in towards its star-like core. Higher magnifications also reveal its elliptical shape well. ☐ **SEEN IT**

3 M110

Another bright satellite of M31 is M110. This is another elliptical like M32, but it is significantly more elongated in a north-south orientation. It is classed as a 'peculiar' galaxy due to the fact that it appears to shows some internal structure in its core. On high-quality images this structure appears to be caused by dark dust clouds. M110 has a lower surface brightness than M32 and appears significantly fainter. It lies 36 arcminutes to the northwest of M31's core, slightly less than twice the apparent distance of M32. M110 was discovered by Charles Messier in 1773 but curiously never made it into his original catalogue. It was appended later in the 1960s. ☐ **SEEN IT**

4 NGC 185

We hop into Cassiopeia for our next object, the dwarf-spheroidal galaxy NGC 185. Start at mag. +4.5 Nu (ν) Andromedae, the brightest star close to M31. Midway between this star and mag. +2.1 Alpheratz (Alpha (α) Cassiopeiae) is mag. +4.5 Omicron (ο) Cassiopeiae. NGC 185 appears as a 9th-magnitude circular patch, 50 arcminutes to the west of this star, with a 6-inch scope revealing an east-west elongation. It appears about 4 arcminutes in size, its brighter core measuring 1 arcminute across. Larger instruments at high powers show that the main halo has a granular texture. Its overall appearance bears more similarity to an unresolved globular cluster. Like M32 and M110, NGC 185 is a satellite galaxy of M31. ☐ **SEEN IT**

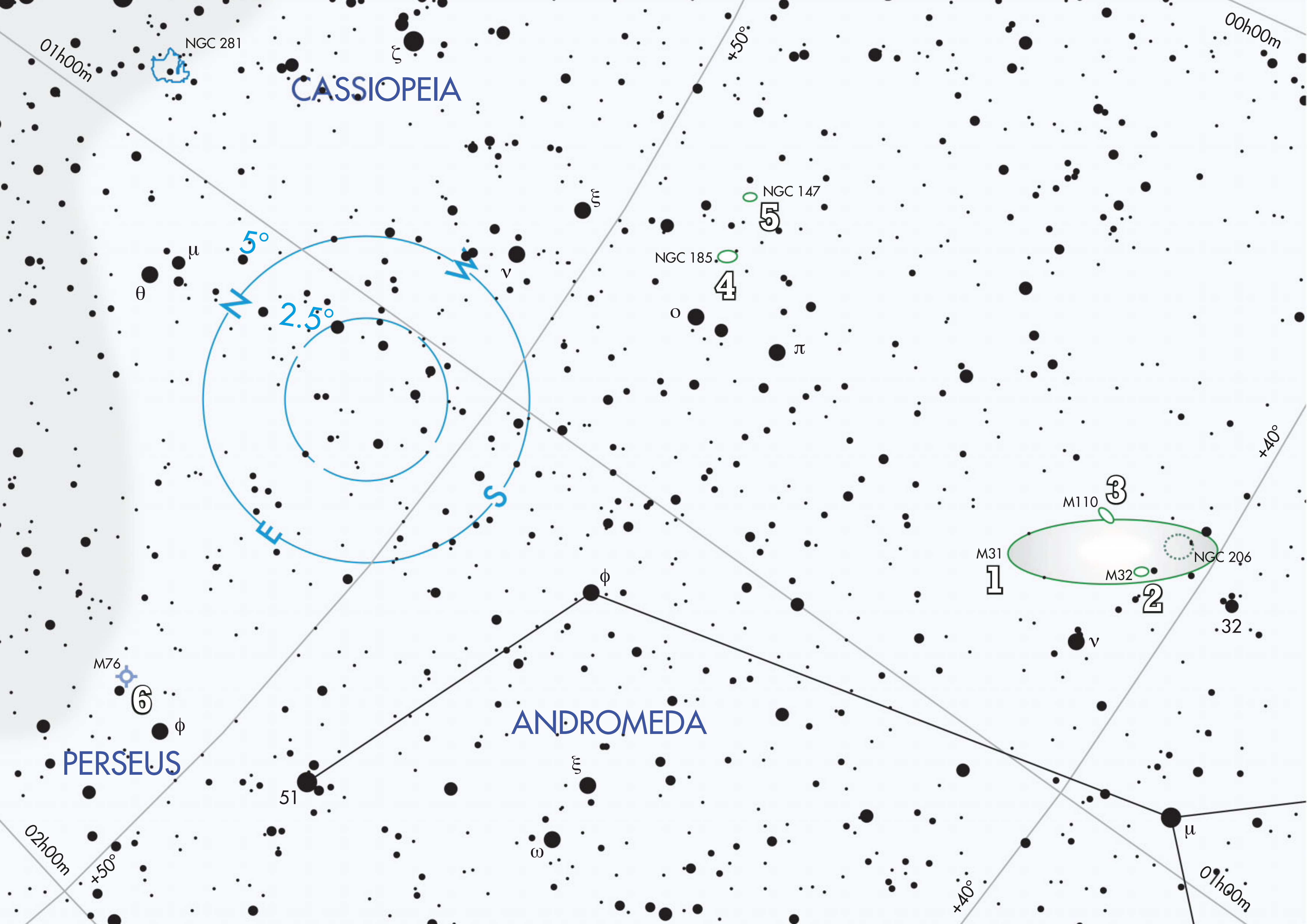
5 NGC 147

Our final galaxy for this month's tour is faint NGC 147 – yet another satellite of M31 – which is located 1° to the west-northwest of NGC 185. It is a bit of a challenge to see because it has a really low surface brightness. A 12-inch telescope shows it as a faint elongated patch brightening in the middle to a star-like core – for the best views, you'll need to use averted vision. Compared to NGC 185, NGC 147 is both slightly larger and fainter. Detailed analysis of the galaxy has revealed that the last significant star forming activity within it occurred three billion years ago. ☐ **SEEN IT**

6 THE LITTLE DUMBBELL NEBULA

We venture back to our own Galaxy for our final object, the planetary nebula M76 in Perseus, also known as the Little Dumbbell Nebula. Find it 50 arcminutes north of mag. +4.0 Phi (φ) Persei. Being one of the faintest Messier objects, it can be tricky to see well. A 6-inch scope shows two unequal lobes of nebulosity, the southwest one appearing brightest, while a 12-inch scope shows both lobes almost isolated from one another. A faint circular halo surrounds this 1.3x1-arcminute structure, and in long exposure images the whole nebula looks like the number eight – the brighter lobes representing the crossing point in the centre of the number. ☐ **SEEN IT**

CHART: PETE LAWRENCE, PHOTO: JOHANNES SCHEDLER/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT


CASSIOPEIA
ANDROMEDA
PERSEUS
NGC 281
NGC 147
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NGC 185
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M110
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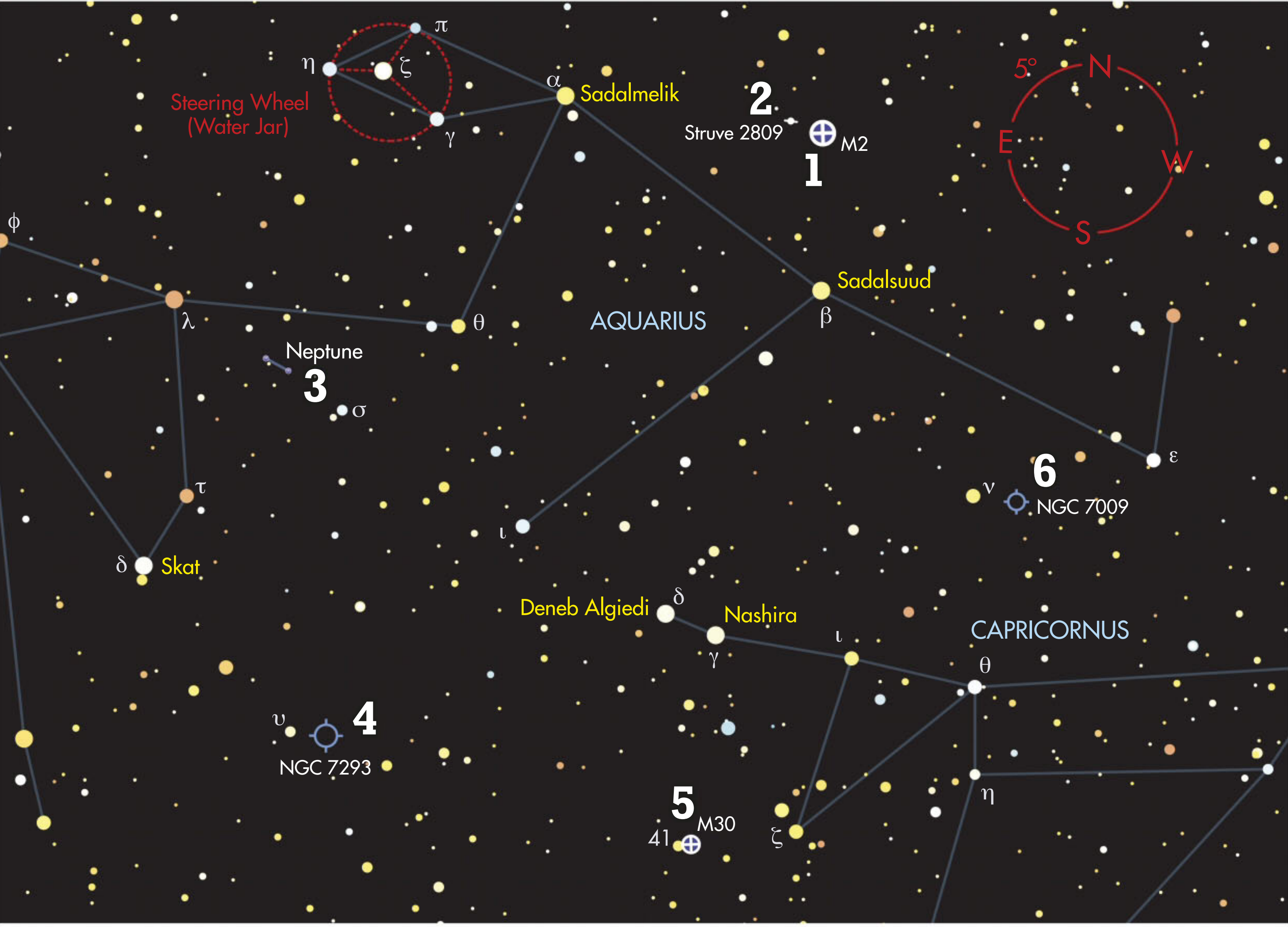


With
Stephen Tonkin

Binocular tour

September brings us a granular globular, a truly planetary nebula and a taxing double star

☑ Tick the box when you've seen each one

1 M2

10x50 Globular cluster M2 is easy to find: it is due north of mag. +2.9 Sadalsuud (Beta (β) Aquarii) and west of mag. +3.0 Sadalmelik (Alpha (α) Aquarii), sitting in a star-sparse region of sky. Even in small binoculars you should be able to see this 38,000 lightyear-distant cluster as Charles Messier described it: "A nebula without stars." If you use averted vision, it will appear to grow slightly and may appear slightly oval in shape. Under good sky conditions, it may also appear slightly granular. ☐ **SEEN IT**

2 STRUVE 2809

10x50 From M2, navigate slightly over 1° east-northeast, where you will find a mag. +6.2 star. This is the brighter member of the double star Struve 2809. The fainter component is a very good test of both 10×50 binoculars and your observing technique, as it only shines at mag. +9.3 and is a mere 31 arcseconds south-southeast of the brighter star. You will need a transparent sky and well-focused, mounted binoculars to give yourself a good chance of seeing it. Don't expect the fainter member to be consistently visible: it will tend to 'fade' in and out of vision. ☐ **SEEN IT**

3 NEPTUNE

10x50 Shining at mag. +7.8, planet Neptune is surprisingly easy to see in binoculars as long as you know exactly where to look. Start at the distinctly orange mag. +3.7 Lambda (λ) Aquarii and navigate 3.5° in the direction of mag. +4.8 Sigma (σ) Aquarii, where you will find a mag. +6.9 star. Neptune starts September just on the Lambda side of this star and, over the course of the month it moves just over 0.75° towards Sigma. It appears stellar in binoculars, and is only identifiable because it moves in relation to the background stars. ☐ **SEEN IT**

4 THE HELIX NEBULA

10x50 A good southern horizon and a transparent sky are essential if you are to observe this planetary nebula, designated NGC 7293. Look 10° south of Sigma Aquarii and you will find mag. +5.2 Upsilon (υ) Aquarii. From there head 1° to the west, where you should see a faint circular patch about 13 arcminutes in diameter. Once you have identified it, see if averted vision will show any tenuous detail. You will not be able to see the helical structure that gives it its name, but you may just notice that the edge, especially to the north, is brighter than the centre. ☐ **SEEN IT**

5 M30

15x70 Globular cluster M30 is smaller and fainter than M2. To find it, start at mag. +3.7 Zeta (ζ) Capricorni. You should be able to see the cluster 3° from this star in the direction of mag. +5.2 41 Capricorni – M30 will have the guise of a slightly defocused star. If you ever intend to do a Messier marathon, M30 is one that you need to practise finding in advance, being the difficult last object in a lightening dawn twilight sky; autumn evenings are a very good time to start this preparation. ☐ **SEEN IT**

6 THE SATURN NEBULA

15x70 For our last object you will need the same conditions as you did for the Helix Nebula – fortunately, the Saturn Nebula, or NGC 7009, is very easy to locate. Start by locating mag. +4.5 Nu (ν) Aquarii. The nebula is 1.3° due west; note also there is a mag. +7.0 star 0.5° to the west-southwest. The nebula will look like a slightly defocused star but, at this magnification, neither averted vision nor a UHC/OIII filter held in front of the eyepiece will show the elongation that gives it its common name. ☐ **SEEN IT**

CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Crater Pitatus

CRATER PITATUS is an old and prominent feature at the southern end of the Mare Nubium, the Sea of Clouds – it almost appears to be an extension of the sea. In many cases where large, high-walled craters lie close to the edge of a lava basin, the basin lava has broken through the ramparts to resurface the crater floor. In the case of Pitatus, it's believed the floor lava welled up from within the crater itself.

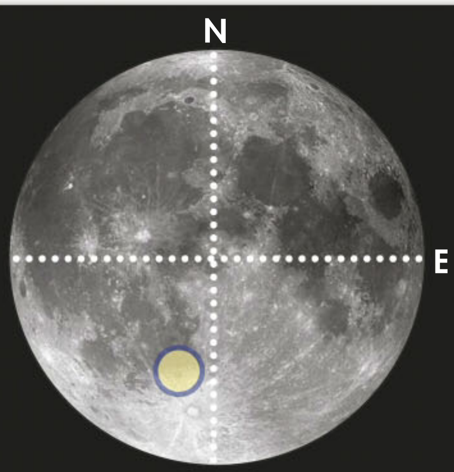
The three-quarter, octagonal-shaped rim appears eroded to the north. Pitatus's smooth floor has a small, central mountain. A rough hilly region lies north of the mountain but the rest of the floor is relatively smooth with just a few tiny craterlets and a number of subtle domes, visible when the terminator is near.

Things start to get interesting closer to the rim. A curious crack, or rille, runs parallel to it. Using a 10-inch scope under steady seeing, the rille can be spotted close to the northern edge of the rim. It follows the inside profile of the crater to the east and round to the southeast. In high-resolution images, you can follow this crack virtually all the way round. A thin rille appears to join the rim to the central mountain to the southwest.

The western rim is odd because it appears gouged out; it's almost as if a giant finger has been run along it, causing a groove. Closer inspection suggests this is a line of small craters, perfectly aligned to the curve of the rim.

STATISTICS

TYPE: Crater
SIZE: 98km
AGE: 3.85-3.92 billion years old
LOCATION: Latitude 29.9°S, longitude 13.5°W
BEST TIME TO OBSERVE: One day after last quarter or first quarter (morning of 6-7 September or evening of 21-22 September)
MINIMUM EQUIPMENT: 2-inch refractor



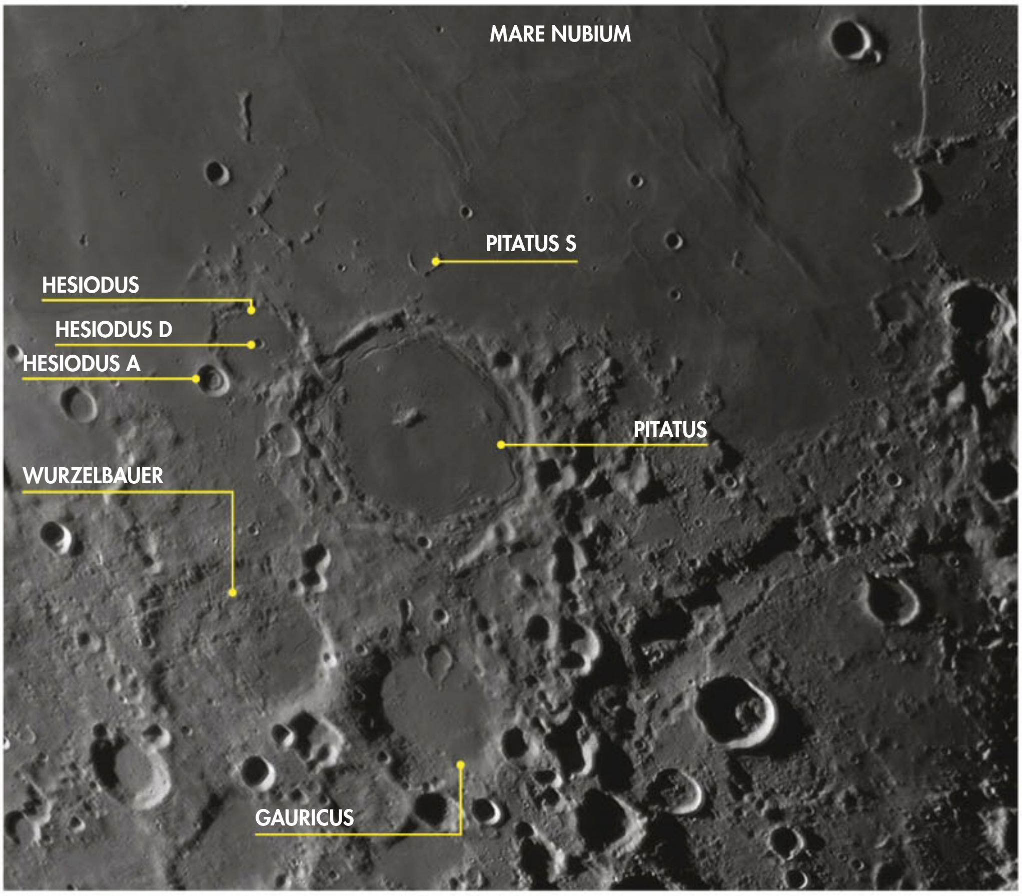
"The western rim appears gouged out, almost as if a finger has been run along it"

The ray crater Tycho lies 410km to the south and slightly east of Pitatus. During the fuller phases of the Moon, bright Tycho (86km wide) and dark Pitatus (98km) look like negatives of one another. When the Sun is high in the lunar sky, Pitatus's floor looks dark, but look closely and you should be able to see patches of bright ejecta from Tycho, which is roughly one-third the age of Pitatus.

Pitatus touches crater Hesiodus (43km) to the west. They are connected by a gap in their rims. Hesiodus has a tiny 5km craterlet at its centre called Hesiodus D. However, the real treat is Hesiodus A (15km), which touches the southern wall of its parent crater. The floor of Hesiodus A has two concentric rings inside it.

Located 73km to the north of Pitatus's centre is a superb horseshoe crater called Pitatus S. Here, a perfectly circular crater has become flooded by Mare Nubium lava. However, not all the crater has disappeared – a delicately thin semicircle of crater wall can still be seen.

While Pitatus is pretty ancient, to the south of it lie two even older craters in the form of Gauricus (80km) and Wurzelbauer (88km). Gauricus has a smooth round cross-sectioned rim surrounding a flat crater floor. Wurzelbauer looks really ancient. Here the rim is ill defined and rather ragged. The floor is old and weathered – extremely rough in contrast to its neighbour.



Take a close look at Pitatus's rim: there is a curious rille running around much of the inside of it

Astrophotography

The lunar occultation of Aldebaran

RECOMMENDED EQUIPMENT

Mono high frame rate camera with infrared-pass filter, DSLR camera, equatorially mounted and driven telescope

Our simulated image of the result, with the sky brightening as the occultation progresses

DESPITE ITS APPARENT size in the sky and the fact that it moves fairly quickly relative to the background constellations, the Moon doesn't often pass in front of a bright star. So when this does happen, it's something that's definitely worth trying to capture on camera.

This type of event is called a lunar occultation. The accurate timing of a star's disappearance and reappearance was an important measurement for determining the accuracy of the Moon's orbit and profile of its edge as seen from Earth. Nowadays, the same technique is used to accurately time occultations of stars by asteroids, a process that can help us determine the asteroid's profile.

This month's imaging project is all about capturing the 5 September lunar occultation of Aldebaran, the alpha star of Taurus. Let's look at the disappearance event first. This occurs at 05:47 BST (04:47 UT) as seen from the centre of the UK, when the dawn twilight is starting to take effect. Any camera lens that can show the Moon as a disc should be able to record the occultation, but the longer the focal length, the more dramatic the view will be.

For a DSLR, a focal length of 200mm or longer is recommended, with 1,000mm producing an optimal image scale to still show the entire Moon and the star. The brightness of the scene means that a low ISO can be used, say around 200-400. Expose so that the Moon's surface is bright but not overexposed; avoid any pure white regions on the surface. This can be checked on the camera via the image's histogram. If you take a series of shots leading up to the actual disappearance, these can be added together to produce a representation of how the Moon closes in on Aldebaran.

Reappearance will be much harder to capture because the Sun will be up. Even so, Aldebaran should record fairly well. For this, you'll need to be ready by estimating where the edge of the dark lunar limb is in the sky; not so easy when you can't actually see it. Here a focal length that keeps the entire Moon in the frame works well, giving you a bit of leeway if your estimate of the reappearance position is slightly off.

For the reappearance set the ISO very low, say to 50 or 100. Your exposures will probably need to be short too, as it will be easy to overexpose the image given the bright daylight sky.

A high frame rate planetary camera can also be used to record the occultation. The use of an infrared-pass filter with such a camera will also help darken the background blue sky, making the star easier to see in your images. DSLR and mono high frame rate camera images can also be combined: the processed shot from the high frame rate camera can be used as a high quality luminance image and added to the DSLR's colour result. Be aware, that unless you have a parallel imaging setup, the Moon-star separation will have changed between captures. This is not so critical for colour data where the real effect you're after is the blue of the background sky.

Given clear weather, it's amazing how well a bright star shines thorough even the brightest of daytime blue skies. Place that star next to the Moon and the whole scene has the potential to create a rather special image.

KEY TECHNIQUE

GETTING THE BIG PICTURE

Lunar occultations are thrilling things to observe but photographically it can be a challenge to capture that excitement in a single image. That's why this month we are going to capture several images of the lunar occultation of Aldebaran and combine them in such a way to reveal exactly what's happening. This particular event will occur as the background sky is brightening, and to convey this we'll go one step further and combine shots taken with a mono high frame rate camera with colour ones from a DSLR.

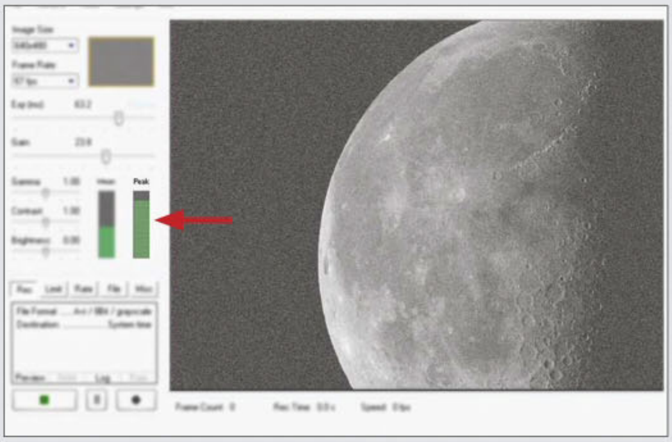
Send your image to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

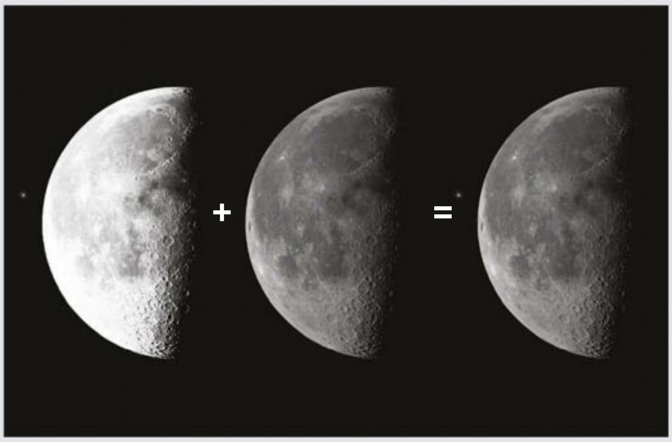
STEP-BY-STEP GUIDE

STEP 1

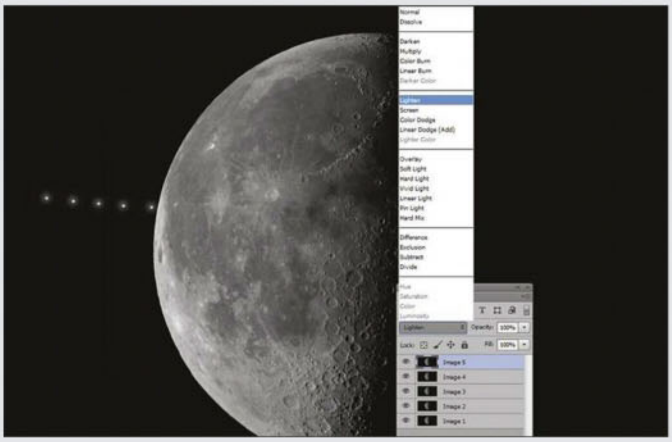
Locate the Moon and Aldebaran in plenty of time before the occultation, say from 05:00 BST (04:00 UT). Actual timings may vary by several minutes for different locations. Select your camera and telescope combination. If using a mono high frame rate camera, consider fitting an infrared-pass filter to darken the background sky and provide greater contrast. Set everything up and point the telescope at the bright lunar limb.



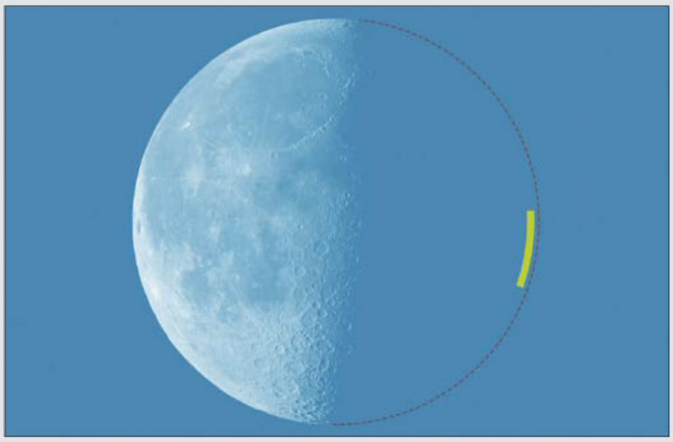
STEP 2 Focus accurately on the limb. Carefully slew to Aldebaran and check it can be seen. Temporarily bump up the exposure and gain if necessary. Now you know the star's position relative to the Moon, swing back to the Moon and adjust the gain and exposure settings so that the surface is bright but not overexposed.



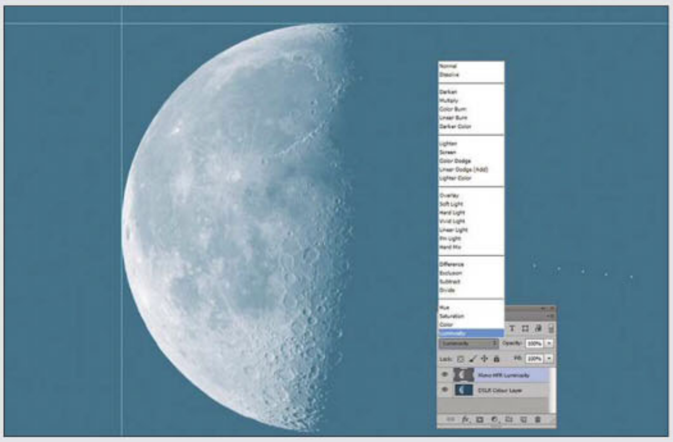
STEP 3 Take a 1,000-frame capture of the Moon. Slew back to Aldebaran and check that it's visible. If you feel you need to push the gain and exposure settings higher to see the star, the Moon will become overexposed. This is okay for positional recording: you can overlay the results from this capture of the Moon on the overexposed results.



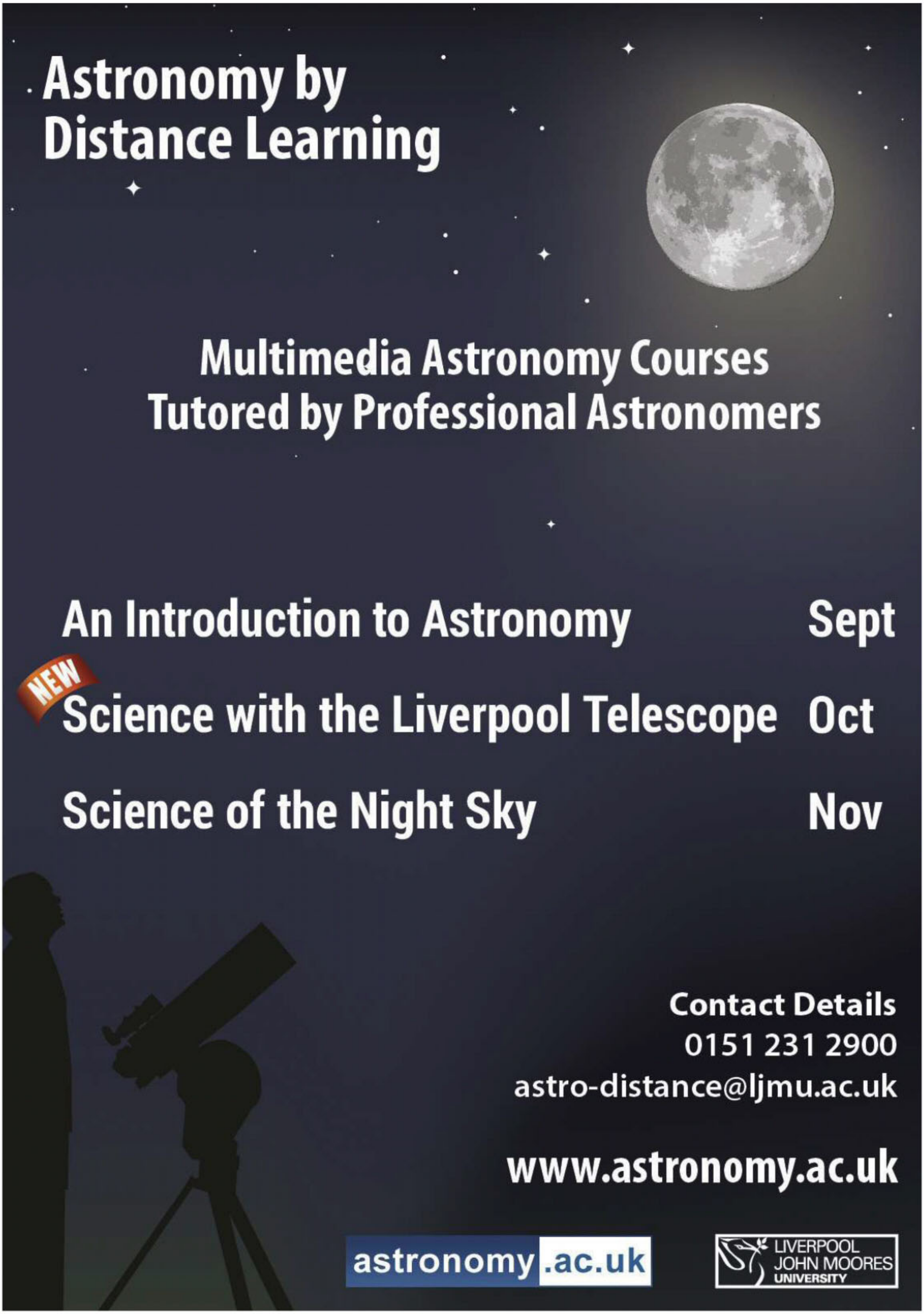
STEP 4 Maintain the Moon's relative frame position with Aldebaran in the shot. Take short captures of 200-300 frames. Repeat every few seconds until the occultation. Process in RegiStax or Autostakkert, using the star as the reference. Layer and align the images in a graphics editor, setting the blend mode to Lighten to show the progress of the event.



STEP 5 You'll need to guess where the star will reappear relative to the Moon's bright limb. It helps to use a low magnification to include some bright surface. Keep levels high but avoid overexposure. Aldebaran reappears at 07:03 BST (06:03 UT) from the centre of the UK. Make short captures at frequent intervals from 06:50 BST (05:50 UT).



STEP 6 Combine reappearance shots as in Step 4. If you also have a colour DSLR shot, open it in a layer-based editor and add a sequence result as an upper layer – scale and align with the colour image and set the layer blend mode to Luminance. If you have both sequences in colour, consider a black to white graduated layer mask to smoothly join them.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Lunar eclipses commonly cause our nearest neighbour to turn red – turn the page to find out why

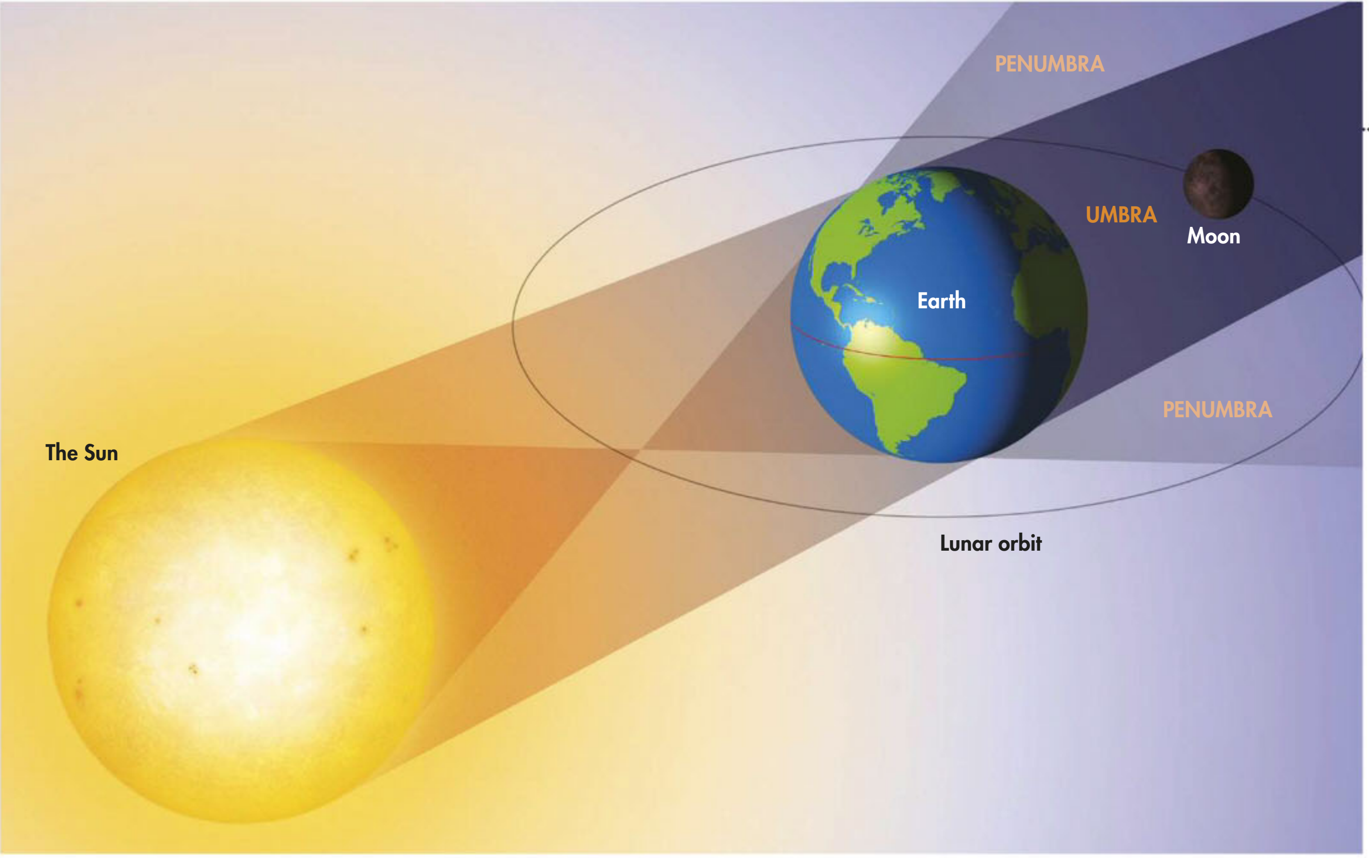
PHOTOGRAPHING THE LUNAR ECLIPSE

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

If you get a good shot of the eclipse, why not enter it into the next Insight Astronomy Photographer of the Year competition? Though the 2015 winners will be announced in mid September, you'll be able to submit entries for the 2016 competition in January next year.

This month's total lunar eclipse is a great astrophoto opportunity. **Pete Lawrence** explains how to get the most out of your shots

PETE LAWRENCE



In the early hours of 28 September, the UK will get its first well placed total lunar eclipse since 2008. A lunar eclipse occurs when the full Moon passes into the shadow that Earth casts in space. Despite the shadow being quite large at the distance of the Moon, the 5° inclination of the Moon's orbit relative to that of Earth means that most full Moons miss the shadow completely. They simply pass above it or below it.

The shape of this shadow is determined by the Sun appearing to us as a circular extended light source, with a diameter of 0.5°. This creates a shadow of two parts: a dark central portion called the umbra and a less intense portion called the penumbra. If you piloted a spacecraft into the umbra the Sun's disc would be completely hidden behind the Earth, but inside the penumbra only part of the Sun's disc would be hidden. Entering the penumbra would result in a drop in light levels, which would become more noticeable as you moved towards the umbra.

If Earth were airless, the umbra would be really dark. However, Earth's atmosphere refracts sunlight and this partially illuminates the umbra. This light is from the red end of the spectrum – shorter wavelengths in the blue region get scattered – so the umbral

▲ **Lunar eclipses occur when the Moon passes into the shadow that Earth casts in space**

BRINGING OUT **THE STARS**

How to image the dark Moon among its stellar companions

During the period of totality, the brightness of the Moon's disc drops significantly and sometimes quite dramatically. By deliberately overexposing the scene, it is often possible to record fainter background stars without having the entire frame swamped by the Moon's light – as would happen during a normal full Moon. A shot showing the background stars can then be combined with a correctly exposed image of the totally eclipsed Moon with graphics editing software to produce a view of totality against the stars.

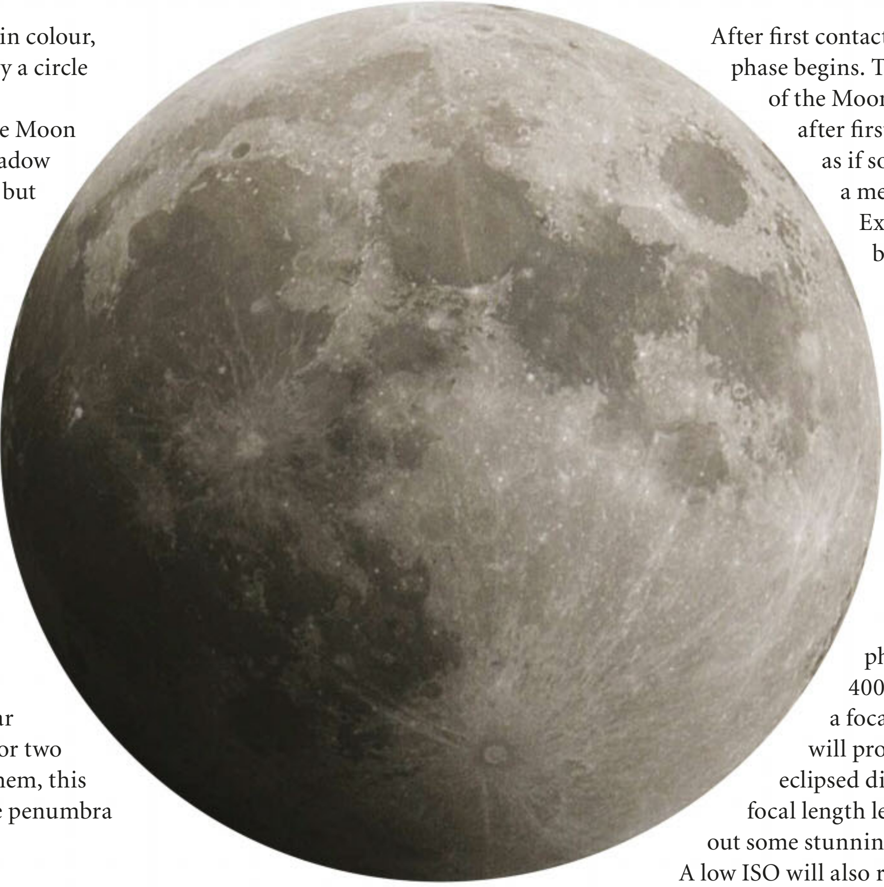
During the 28 September eclipse, the Moon will be located in the constellation of Pisces, 8.5° to the east and slightly south of the Circlet asterism. This is not a region known for bright star fields, but there are a few which can be picked out. Use a 135mm or shorter focal length lens on a non-full frame DSLR – this should allow you to capture the eclipsed Moon and the Circlet together.

▲ **Normally the glare of the full Moon would blot out any stars, but during totality it is possible to record them too and add them to your eclipse image when processing**

MARK GARLICK/SCIENCE PHOTO LIBRARY, PETE LAWRENCE X 4

shadow appears reddish in colour, essentially illuminated by a circle of sunsets and sunrises.

The leading edge of the Moon enters the penumbral shadow at 01:12 BST (00:12 UT), but as the penumbra tends to be very weak at its outer extremes you are not likely to be notice this transition. As the Moon passes towards the umbra, the amount of light it receives decreases. This will be most noticeable close to the Moon's western limb, which rather confusingly lies to the east. By taking correctly exposed photographs of the Moon's disc at regular intervals – say a minute or two apart – and animating them, this gradual darkening of the penumbra can be revealed.



▲ **The umbral partial phase begins with a 'melting bite' that can be seen on the lower left of the image above**

The melting Moon

The penumbra is about 0.5º wide, similar to the apparent diameter of the Moon. It takes the Moon just less than an hour to cross it. This first contact with the umbral shadow occurs at 02:07 BST (01:07 UT) and the western edge of the Moon will have become significantly darker just before this time.

After first contact, the umbral partial phase begins. The visual appearance of the Moon looks quite odd after first contact, almost as if something's taking a melting bite out of it. Expose a photo for the bright portion of the Moon's disc and the umbral shadow will appear dark, without features. If you increase the exposure red-hued detail will appear inside the shadow, but the bright surface will become overexposed.

During the partial phase, a low ISO of 200-400 is ideal. A lens with a focal length of 100mm will produce a recognisably eclipsed disc, but a 1,000mm focal length lens will really bring out some stunning detail.

A low ISO will also result in a better tonal range. This is really important for the edge of the umbra, where the colours can be glorious. The umbra itself may appear anything from a golden orange to a deep blood red. At the edge, subtle yellows and grey-blue bands may be recorded. The blue seen here is due to light refracting through the Earth's ozone layer; in ▸

SNAP WITH YOUR **SMARTPHONE**

Capture the action with the camera you have in your pocket

Photographing the Moon with a smartphone is best done by pointing the phone down the eyepiece of a telescope. A low- or medium-power eyepiece works best, though you'll also need a steady hand to line everything up.

Start by holding the phone some distance away from the eyepiece and gradually bringing it closer, while guiding using the phone's screen. Once in position, carefully press the shutter button. If you have headphones with a volume control on the lead, try plugging them in and using the controls while in the camera app. On some phones these controls trigger the shutter and thus reduce camera shake.

Your camera's automatic functions should adjust the settings for you, but remember to turn the flash off beforehand. This should work well for the partial phases but the totally eclipsed Moon may be a bit hit and miss as it's difficult to say just how dark it's going to be. The best advice here is just give it a go.

▸ **This iPhone image of the Moon shows the quality modern smartphones are capable of**

▲ **Aiming a camera down the eyepiece of a telescope requires a steady hand, both to keep it in line and avoid shake when pressing the camera button**

▸ this case it's the red light that gets scattered, leaving blue to pass through.

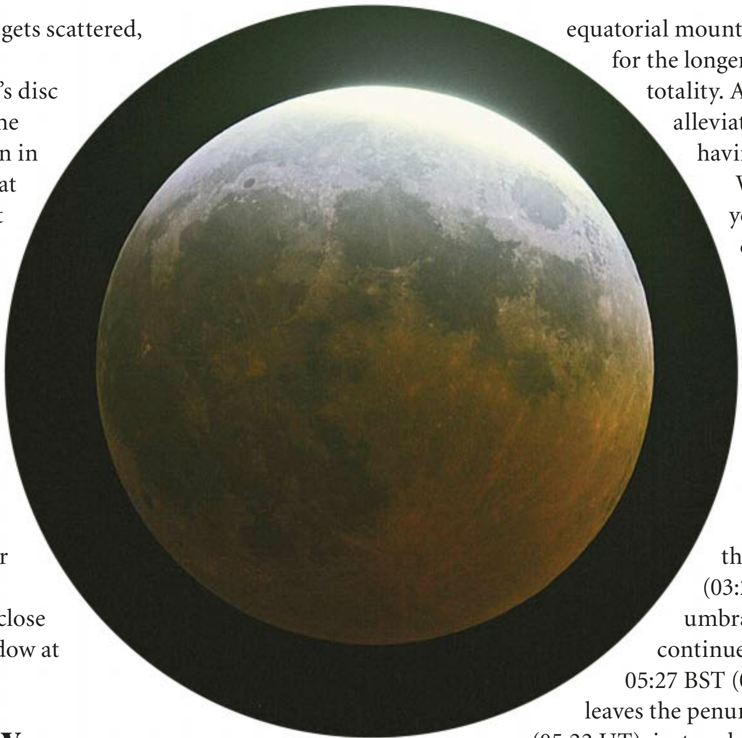
The last portion of the Moon's disc to darken will be that close to the southeast limb. Total immersion in the umbral shadow is achieved at second contact, which occurs at 03:11 BST (02:11 UT). Totality, as it is known, is easier to deal with photographically as there's no bright surface visible to overexpose.

The Moon's disc doesn't pass centrally through the 1.4°-wide umbral shadow, but just south of centre. Consequently, the southern edge of the Moon should appear brighter than that to the north. The northern limb passes very close to the centre of the umbral shadow at 03:47 BST (02:47 UT).

The trials of totality

The exact colour and darkness of totality isn't easy to predict. Some are very dark with the Moon virtually disappearing from view. Others are light, showing a golden-yellow colour. The variation means that reviewing camera feedback is really important to get the exposure right.

It's important to check the camera's histogram regularly. A good result shows the tone value 'mountain' peaking between the left and right extremes of the graph (the black and white points). If they sit hard against either end, then your image is either underexposed or overexposed. Keeping the lens aperture wide and exposure short will alleviate problems caused by the Moon's movement or from wind shake. A fixed tripod is great but a driven equatorial mount makes life easier, especially for the longer exposures needed during the totality. A remote shutter release will alleviate shakes caused by physically having to press the shutter button.



▲ The colours that may appear on the edge of the umbra can vary enormously – from grey-blues to golden hues

When totality finally arrives, you will need to raise the camera's sensitivity. This is done by raising the ISO or lengthening exposures. A dark totality can surprise, so be prepared. The best advice is not to panic: there's plenty of time to take it all in – this totality will last for 72 minutes.

Totality officially ends with third contact at 04:23 BST (03:23 UT). After this the second umbral partial phase begins. This continues until fourth contact at 05:27 BST (04:27 UT). The Moon finally leaves the penumbral shadow at 06:22 BST (05:22 UT), just as dawn starts to take hold.

Everyone will have their fingers crossed for clear skies on 28 September, but if the worst should happen, there's a partial lunar eclipse visible at moonrise on 7 August 2017, another total eclipse, again visible at moonrise, on 27 July 2018 and another reasonably well placed total lunar eclipse on 21 January 2019. Ⓢ

ABOUT THE WRITER

Expert imager Pete Lawrence is a regular on the *The Sky at Night* and *Stargazing LIVE*. The author of several books, he also compiles our monthly *Sky Guide*.

CREATING A **SEQUENCE**

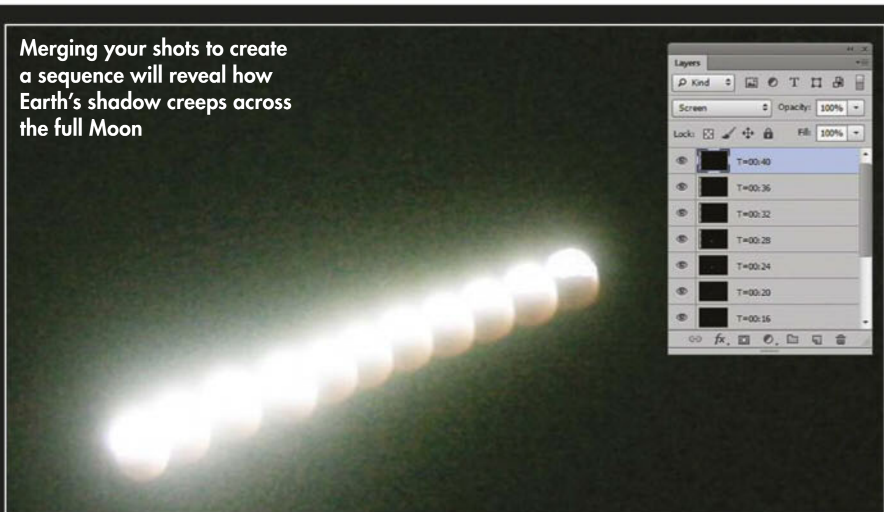
Combine shots to record the shadow's progress

A wide-field camera on a fixed tripod can produce a stunning eclipse sequence. Use a low ISO of 200-400 and expose so the full Moon appears bright to the point of being almost overexposed. Take shots at regular intervals, say four minutes apart.

Load each image into a layer-based editor and draw a circular selection around the Moon with 2-5 pixel feathered edges. Invert the selection, create a new layer above and fill with black. Save these Moon-only shots with a sequence number – for example 001.jpg, 002.jpg and so on.

Load each Moon-only image into a separate upper layer with blend mode set to Lighten. Merge with the layer below. Pick an original image with a good sky and load as the top layer; set its blend mode to Lighten too.

A 12mm or shorter lens, aligned so that south is at the left frame edge, should contain the entire eclipse including the penumbral phase, from 01:12 to 06:22 BST (00:12 to 05:22 UT). A 20mm lens should be able to cover the umbral phase from 02:07 to 05:27 BST (01:07 to 04:27 UT).



Merging your shots to create a sequence will reveal how Earth's shadow creeps across the full Moon

PETE LAWRENCE X 2

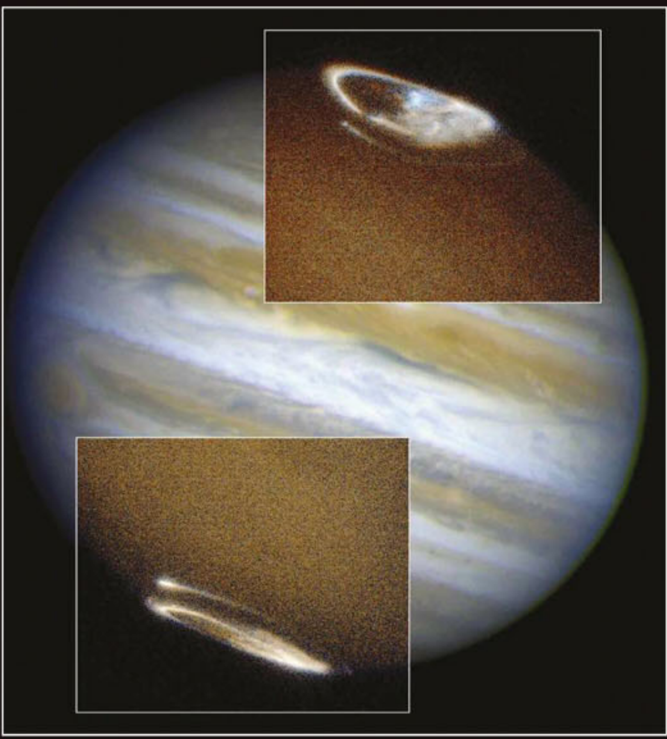
THE DANCING LIGHTS OF DISTANT WORLDS

It is not just our planet that is treated to a dazzling light show around the poles, writes **Elizabeth Pearson**

Seeing the aurora is part of any astronomer's bucket list. On Earth, they occur when charged particles from the Sun are caught in our magnetic field, which funnels them towards the poles; when these particles strike atoms in our atmosphere, they cause those atoms to become 'excited' and release a cascade of light, which we see as the aurora. The green hue most associated with the aurora comes from our oxygen. But this isn't a universal recipe: though many skies of the Solar System dance with light, each one is unique.

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University.



▲ Aurorae visible in ultraviolet have been witnessed above Jupiter's poles, and extend hundreds of kilometres above the planet

JUPITER

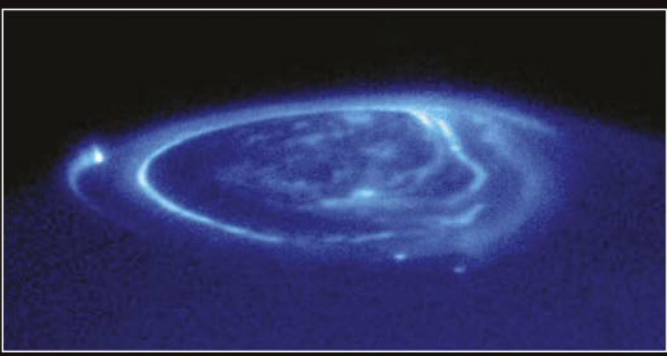
For most planets it is the solar wind that drives the aurora, but for Jupiter this isn't so. The king of the Solar System is unique in that it is the only planet to generate its own auroral displays.

The planet has a huge magnetic field, 10 times stronger than the Earth's and 18,000 times larger. The gas giant is also spinning much faster, once every 10.5 hours, and this spinning in a magnetic field generates a voltage of 10 million volts around the poles.

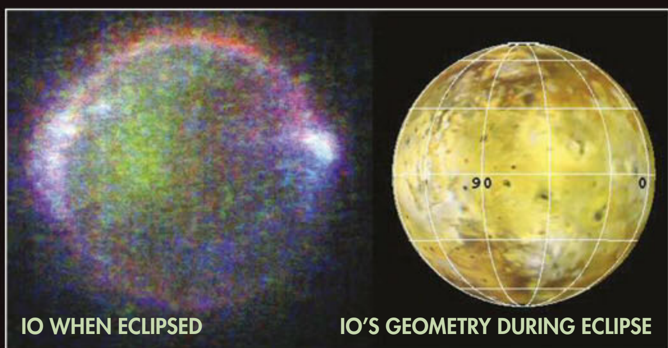
This huge electric field drags in any nearby charged particle, and the nearby volcanic moon Io is constantly pumping out sulphur around the planet. These particles slam into Jupiter's atmosphere, resulting in an intense aurora of green, red and purple, but they also shine strongly in the ultraviolet and X-ray.

This huge field doesn't only cause aurorae on the planet though. The charged plasma also creates celestial lights on any of the Jovian moons with an atmosphere. So it would be possible to stand on the surface of Ganymede or Io and watch an aurora on Jupiter through an aurora of its own.

► Aurorae have also been seen in X-rays; they may be caused by sulphur and oxygen ions interacting

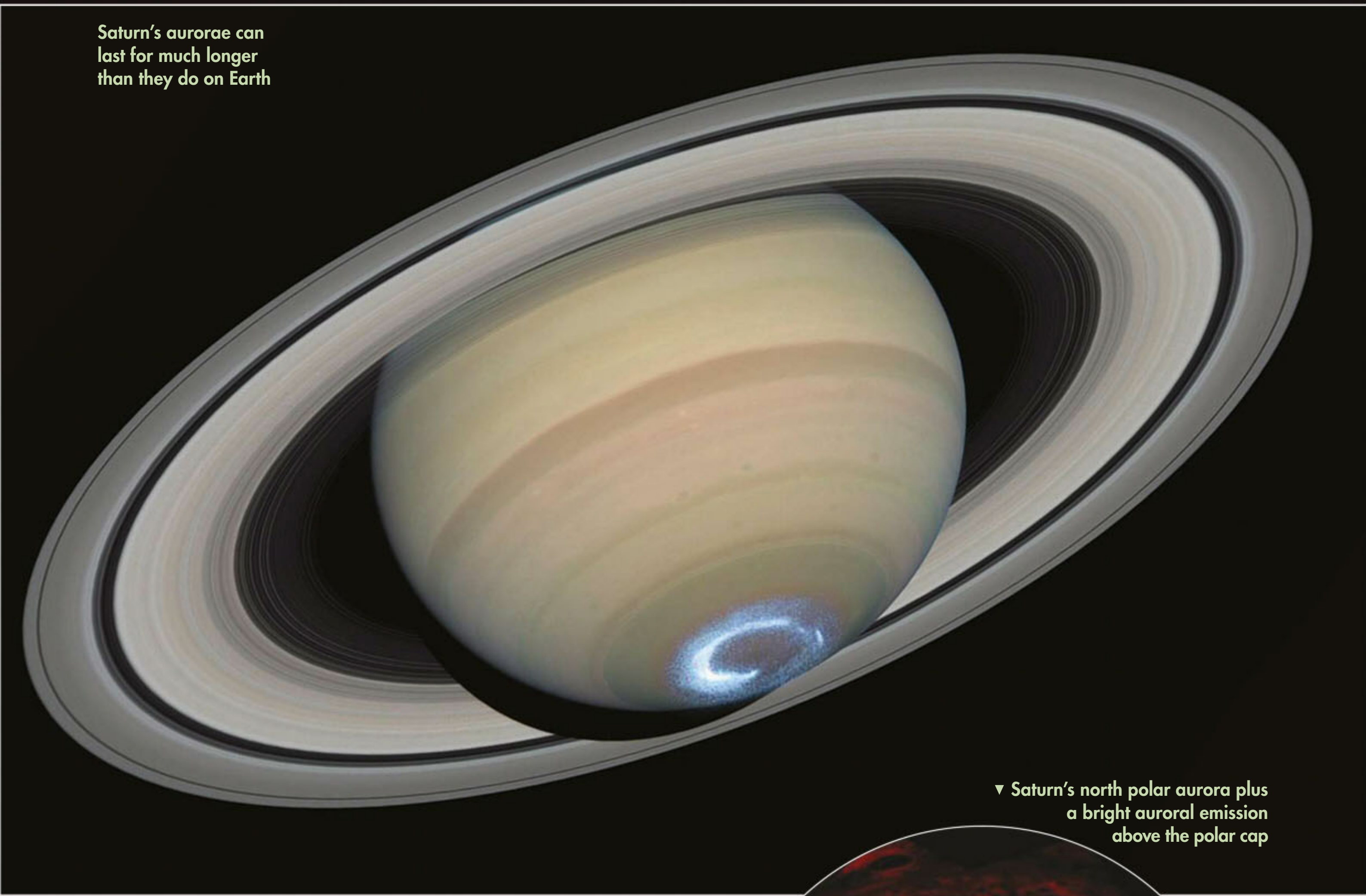


▲ Jovian aurorae like this one – witnessed over the planet's north pole – can also hold the magnetic 'footprints' of its major moons



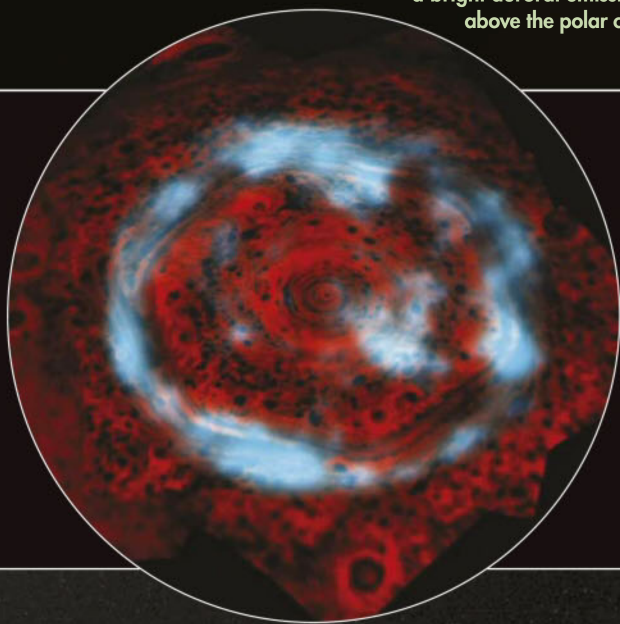
▲ NASA's Galileo probe discovered vivid hues on an eclipsed Io – caused by interactions between its atmosphere and Jupiter's magnetic field

JPL/NASA/STSCI, NASA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA) ACKNOWLEDGMENT: NASA/ESA, JOHN CLARKE (UNIVERSITY OF MICHIGAN), NASA/JPL/UNIVERSITY OF ARIZONA X 2, X-RAY: NASA/CXC/SWRI/R.GLADSTONE ET AL.; OPTICAL: NASA/ESA/HUBBLE HERITAGE (AURA/STSCI), NASA/ESA/J. CLARKE (BOSTON UNIVERSITY) AND Z. LEVAY (STSCI), NASA/JPL/UNIVERSITY OF ARIZONA/UNIVERSITY OF LEICESTER, NASA/JPL-CALTECH/SSI



Saturn's aurorae can last for much longer than they do on Earth

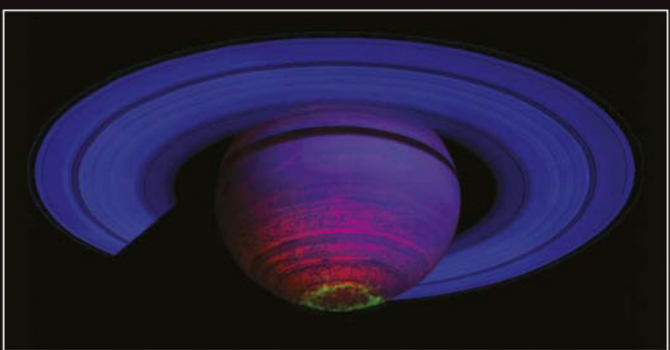
▼ Saturn's north polar aurora plus a bright auroral emission above the polar cap



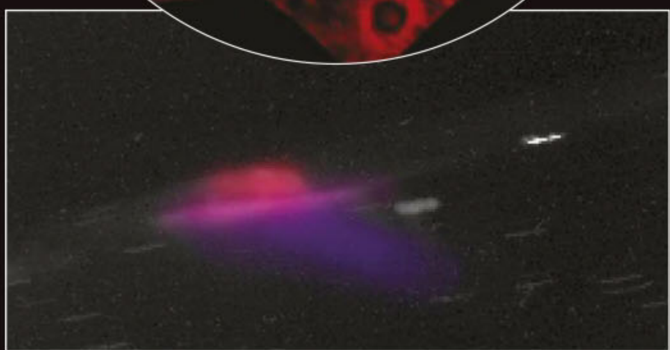
SATURN

Like Jupiter, the Ringed Planet has a huge magnetic field, if not quite as strong. It is also lopsided, meaning that the auroral displays at the north pole are much brighter than at the south and can last for over 15 hours. Rather than being a typical ring-like structure crowning the planet, the aurorae cover the entirety of the pole.

Saturn's aurorae are mostly red due to the hydrogen that dominates the atmosphere, but they also shine brightly in the infrared, though this is invisible to human eyes. And on this world they are more than just a pretty light show: they have an effect on the planet's atmosphere. For decades scientists have wondered why portions of Saturn's atmosphere were warmer than others. Now it appears that they are being heated by these intense auroral displays.



▲ This false-colour image in near-infrared reveals aurorae streaking out by about 1,000km from Saturn's south polar region

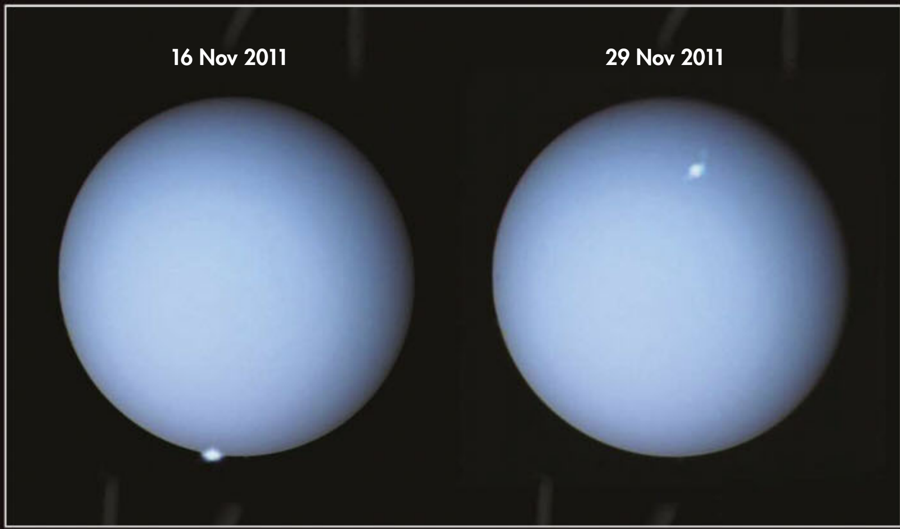


▲ On Earth aurorae are mostly green, but on Saturn they would appear predominantly red and purple to the human eye

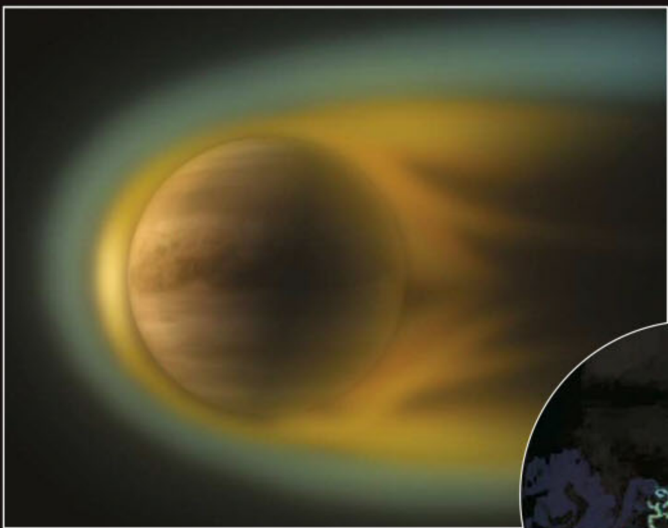
URANUS AND NEPTUNE

Despite their distance from the Sun and its waves of charged particles, aurorae have been spotted on the ice giants Uranus and Neptune. In 1987, Voyager 2 managed to spot aurorae on Uranus, and since then the lights have been spotted on both it and Neptune by the Hubble Space Telescope.

Both of the planets' magnetic fields have unusual orientations – Neptune's is at 47° to its axis of rotation, while Uranus not only orbits the Sun on its side, but also has a field tilted at 59°. Uranus's field is so jumbled that once a day each of its poles is aimed directly into the solar wind. The result is unpredictable, short-lived aurorae that jump around the surface of the planet.



▲ Uranus's aurorae appear far from the poles as its magnetic field is inclined 59° from its spin axis



▲ Without a magnetosphere, Venus is bombarded by the solar wind – but it may have aurorae nonetheless

► Green aurorae may also be seen on the night side of Mars, as depicted in this illustration

VENUS AND MARS

It was previously thought that a global magnetic field was a key ingredient to auroral displays, yet traces have been seen on both Venus and Mars, despite both lacking a magnetosphere.

Venus is so close to the Sun that the bombardment of the solar wind against its atmosphere is strong enough to excite the particles into giving off a detectable glow, even without the focusing effect of a magnetic field channelling the charged particles onto a specific area. Though it's not enough for the human eye to pick out, spectrometers have found the distinctive green glow of aurora spanning the entirety of Venus's night side.

On Mars, we have not only spotted an ultraviolet glow, but NASA has predicted that blue aurorae could be visible from the surface of the Red Planet. The key lies in the planet's past. Mars had a molten core when it formed, and this created a magnetic field. Over time the planet cooled, the core solidified and the field disappeared. However, small patches of the field have remained, frozen into the planet's surface by meteorite impacts, and this can create localised patches of aurorae. One day future astrotourists may travel to Mars's south pole to watch blue lights dancing over the Red Planet.

EARTH

While no location can be assured of a display, there are many places where aurorae can be seen

▲ REYKJAVIK, ICELAND

The landscape around Reykjavik offers a stunning backdrop to the Northern Lights, while the city has a lot of attractions during the day. The lights can be appear any night between October and April.

▲ TROMSO, NORWAY

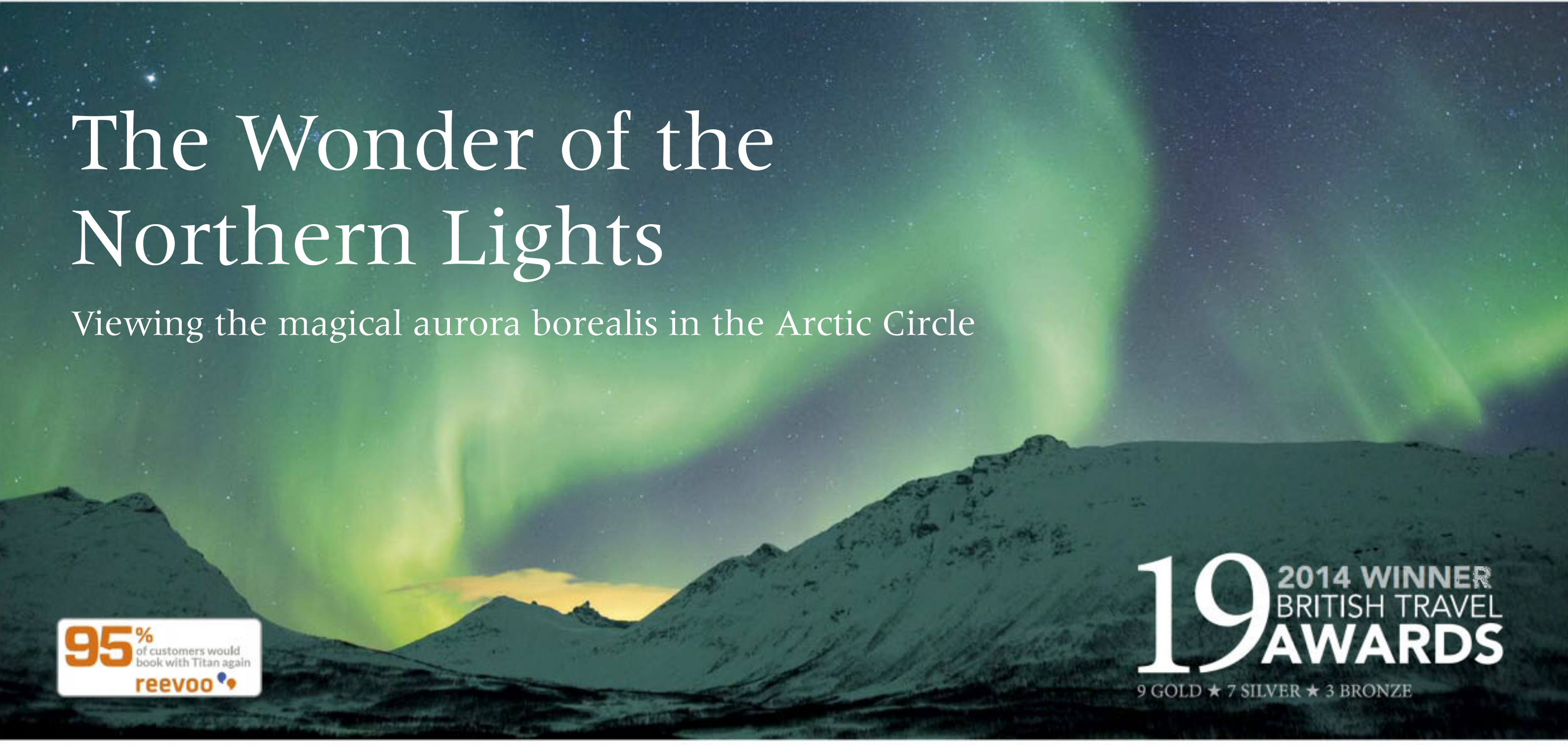
The town of Tromso in northern Norway is one of the best places in Europe to see the aurora borealis, so there are plenty of amenities for aurora hunters, though it can get very busy in peak season.

▲ FORT MCMURRAY, CANADA

Located in northern Canada, this city boasts a 90 per cent chance of seeing the aurora over a three-day stay. Though light pollution is high in the city, a short trip to the countryside is all that's needed to reveal the lights. Ⓢ

The Wonder of the Northern Lights

Viewing the magical aurora borealis in the Arctic Circle



The awe-inspiring spectacle of the Aurora Borealis (Northern Lights) has held watchers spellbound since the dawn of human history. Countless legends arose to explain these extraordinarily beautiful swirls of greens, yellows and reds shimmering against the night sky, from celestial dragons to the spirits of vanquished warriors. Knowing their scientific origin - as charged particles borne on solar winds to the earth's magnetic pole - in no way detracts from their magnificence or modern-day appeal. Our fascinating cruise itinerary, set entirely within the Arctic Circle aboard one of Hurtigruten's excellent vessels, maximises the likelihood of experiencing this mesmerising phenomenon.

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Day 4 Kirkenes - Berlevag. We arrive in the sheltered harbour of Kirkenes, a mere 10km from the Russian border and the Sami communities of Northern Finland. Whilst here, there is the opportunity to join an optional excursion to visit the amazing Snow Hotel. Our adventure continues this afternoon as we sail southwards, crossing Varangerfjord, a fabled bird-watching site.

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2	~~£1,799~~	£1,699	~~£1,799~~	£1,699
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GETTING A FEEL FOR SPACE

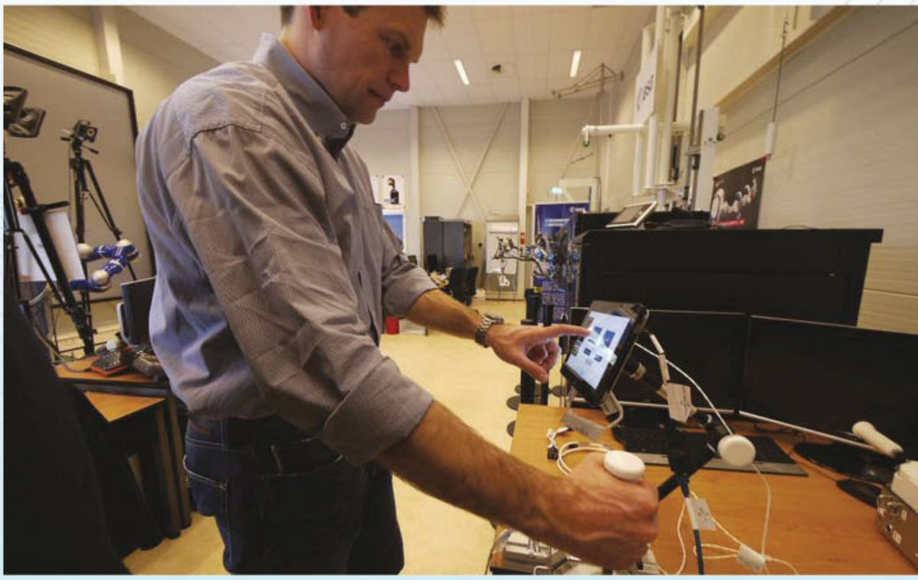
The way we use robots to explore the Solar System is about to change. **Elizabeth Pearson** looks at this new face of robotic exploration

From the surface of Mars to comets, robots have played a huge role in how we have ventured out into the Solar System over the past 60 years. In all that time, there has always been a control team on Earth, making decisions about where our distant emissary is going to travel to and what it will do. Now a new set of experiments on the International Space Station (ISS) could revolutionise the way humans and robots work together in the exploration of not only our own world, but many others as well.

In September, ESA astronaut Andreas Mogensen will take part in the Interact demonstration experiment, becoming the first human to pilot a robot on Earth from orbit. But not only will he control the robot; he'll be able to feel what it feels.

The experiment is being run at ESA's Telerobotics and Haptics Lab, where scientists have been investigating the orbital use of haptic technology – haptics being equipment that lets you feel forces and vibrations. A joystick sent to the ISS in 2014 has already allowed the crew to control a simple game-like experiment on a connected tablet, investigating how microgravity affects haptic feedback to astronauts. Already they have found that the weightless environment reduces astronaut ability to feel the joystick when it was mounted on the wall. In space, pushing on a stiff object causes you to move rather than feel resistance. Luckily this problem can be softened by attaching the stick directly to the astronaut via a harness.

Being able to feel what you're doing is very important to accomplishing fine tasks. Think about when you come in on a cold day and your fingers have gone numb; something as simple as tying your shoelaces becomes impossible. For the many robotic operators without haptic feedback, this is how they must constantly operate.



▲ Mogensen tests a model of the joystick he will use on the ISS to control the Centaur robot (below) on Earth for the Interact experiment

From remote control roving...

But the new Interact experiment will attempt to give robot operators some of the feeling back. It will see Mogensen attempt to operate a robot named Centaur, which has two robotic arms with hands that can be used to grip and manipulate tools. Using a tablet to display the terrain and controls, Mogensen will manoeuvre the robot towards a task board placed in an unknown location some distance away. Once there, he will pick up a peg and attempt to thread it into a hole less than a millimetre bigger.

"He can use the joystick to put a peg into a hole on the board, and if he is well aligned he should – in principle – receive very little force-feedback on the stick," says André Schiele, associate professor at Delft University of Technology and head of the lab. "If he is not well aligned he will instantly feel that he is blocked and can then use the tablet to finely adjust the robot arm."

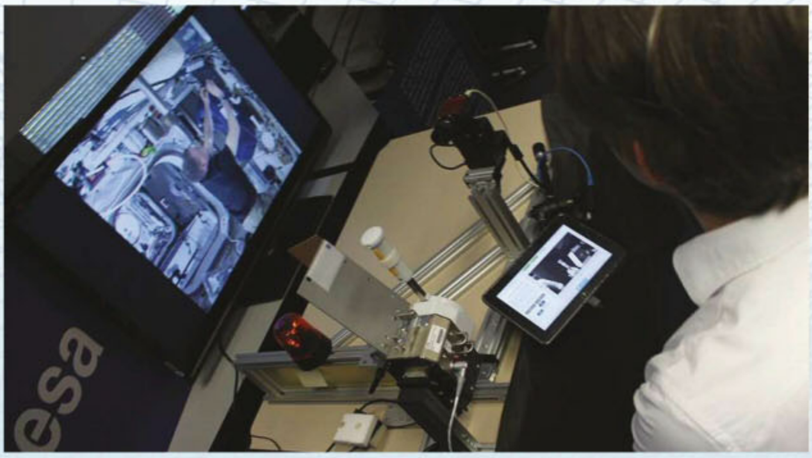
The experiment is a stepping stone to a more audacious plan of controlling rovers on other planets such as Mars.

"Some people want to send humans to Mars and leave them there," says Schiele. "We believe if we send humans there we have the responsibility to bring them back. The only feasible way to do that is to put them into orbit."

Instead, robots would take the risks of landing on another planet, controlled by the crew in orbit, a practice known as telerobotics, allowing the rovers to perform much more complex tasks than current Martian vehicles. Haptics is an important part of this control, for example allowing operators the ability to feel if a drill is sticking on a dense rock; they can then back off before causing damage. ►

◄ ESA's latest full arm exoskeleton is controlled by the whole body and allows the user to feel what the robot can feel

ESA–A. LE FLOC'H, ESA–J. HARROD, ESA TELEROBOTICS/TU DELFT



▲ Schiele waits to perform the landmark handshake from Earth to the ISS with NASA astronaut Terry Virts

▸ Theoretically this could be done from Earth, but it's made nearly impossible due to the time delay of several minutes involved in communication. If the controlling crew were in orbit it would only take a fraction of a second to send and receive signals. However, even this might prove too much.

"There is 0.8 seconds of time delay to the ISS," says Schiele. "Imagine you are driving a car and if you steered left it only turned 0.8 seconds later. It would be pretty difficult to drive."

The delay stems from communicating with a network of geosynchronous satellites that allows for complete global coverage. The length of the lag was tested during the Haptics-2 experiment in June 2015, in which NASA astronaut Terry Virts performed the first handshake from space with Schiele, who was in his lab in the Netherlands.

To mediate the delay, the team used modelling and software to pause the robot arm when it encounters a problem, stopping itself while it informs the user of the problem through haptic feedback, preventing damage. How much this small lag affects operational performance will be one of the things that Mogensen will be investigating during Interact.

If the problems of time delay can be overcome, this can have a huge effect on the capabilities of telerobotics when using the system closer to home. Haptically controlled robots are already being used in medicine, deep-sea exploration and emergency operations, such as those following the Fukushima nuclear reactor disaster in Japan in March 2011, but they often need to use the same satellite communication and suffer the same time delay.

... to a classic sci-fi exoskeleton

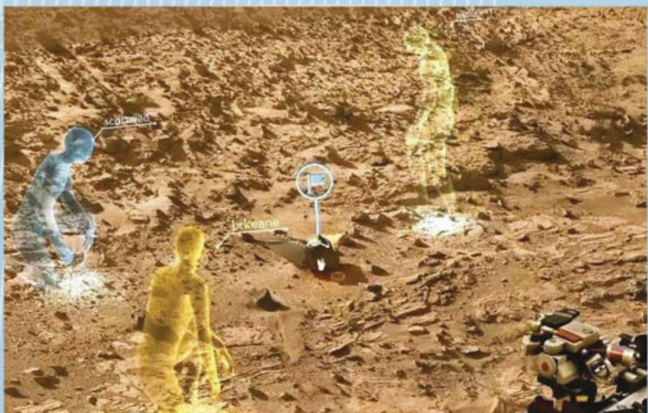
However, Interact is only the first step to beginning routine telerobotic operations in space and the next stage is already being planned – Schiele and his team are working on a more advanced control system than the current single-axis joystick.

"We are preparing a new experiment that will be launched in late 2016," says Schiele. "We've built a full arm exoskeleton that we will fly to the ISS."

This exoskeleton, the fifth generation developed by the lab, allows the user to control a robotic

AUGMENTING **REALITY**

Bringing touch to robotics is important, but without visuals operators are blind



▲ This 3D simulation of Mars uses real data from rovers on the planet

▲ NASA and Microsoft are testing the HoloLens for use on the ISS

Video feeds in space are usually very bad. Suffering from low bandwidth speeds, videos are necessarily low resolution, come from limited angles and have little representation of depth. Performing complex tasks with only this would be like trying to fix a car in a darkened room, where you can't move your head and have one eye shut.

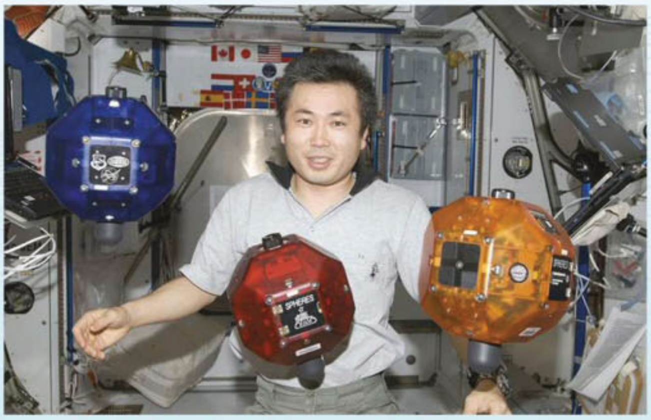
On the ISS, the problem isn't so bad thanks to an entire network of satellites providing internet speeds around the same as those found in the average UK home. But as exploration moves farther out into the Solar System, the quality of video is only going to get worse.

To make video clearer, ESA use augmented reality – overlaying information and 3D models onto real-world images to make them more understandable. 3D glasses can also be used to help gauge depth while information such as the predicted path of the robot arm can make tasks much easier. Meanwhile, NASA is experimenting with Microsoft's HoloLens, a headset that projects an image directly into your eye. Their goal is to allow planetary scientists to create computer models of objects and terrain imaged by Curiosity so they can examine them in a more natural way, helping to make decisions such as what direction the rover should go in. It's hoped that a set will be making its way to the ISS soon.

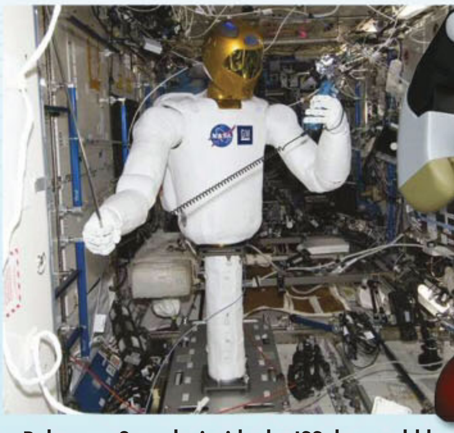
MEET THE **ROBOTS**

The ISS is already home to several robotic helpers

► **Kirobo can hold a conversation – but only in Japanese**



▲ **The floating SPHERES propel themselves around the ISS via thrusters**



▲ **Robonaut 2 works inside the ISS, but could be upgraded for EVAs**

For years there have been experimental robots on the ISS, prototypes for future helpers that can perform boring, repetitive or dangerous tasks and free up time for astronauts to do other things.

The ISS has been home to a mini-fleet of three floating orbs, called SPHERES, since 2006. The probes use carbon dioxide thrusters to propel themselves around the station and are used to test software and hardware that needs to move freely in space. They're already being adapted into robot helpers with the addition of a smartphone, making them mobile monitoring stations, checking the environment on the ISS.

A human-like helper is resident on the station in the form of Robonaut 2. The robot has human-like features and is highly dexterous, allowing it to use many of the tools astronauts can. Currently the robot is limited to life on board the station, but future updates aim to allow the robot to travel outside so that it can aid astronauts during challenging EVAs.

As well as maintaining the physical environment, robots could also help with keeping astronauts in peak psychological condition. A Japanese robot named Kirobo was sent to the ISS as space's first companion robot. The friendly looking robot is loaded with face recognition and cutting edge language software, which allowed it to chat with JAXA astronaut Koichi Wakata. With trips to Mars lasting at least two years, similar robots could help astronauts deal with the isolation of space travel, though Kirobo might have to learn a few more languages as it currently only speaks Japanese.

arm with their body, rather than just their fingers. The two are linked together so that when the user moves, the robot arm mirrors the motion. If the robot then comes across some resistance, the exoskeleton responds, making it harder to move.

During *Stargazing LIVE* 2015, Dallas Campbell was sent to the Netherlands, where he was able to shake hands with Brian Cox and Dara O'Briain at Jodrell Bank using a prototype exoskeleton and the Centaur robot.

"It's your classic sci-fi exoskeleton," says Campbell. "You are in complete control. You put your arm in, and you can wear it. It's not very heavy, it feels very natural. You get used to it strangely quickly. The great thing about it is the haptic feedback. It's not just saying, 'Hey I've got a robot arm!' You can actually feel what the other arm can feel."

Not only is the exoskeleton much more intuitive to use than a joystick and buttons, it's also a lot easier to use, especially in situations where you can't fully use your hands, such as during a space walk. Spacesuit gloves are notoriously difficult to work in, making even turning a spanner an ordeal. Being able to control a robot to perform these finer tasks could make dangerous extra vehicular activities (EVAs) much faster and easier.

"It would have been impossible to do something like this 20 years ago," says Campbell. "It's organisations like this that push the frontiers of technology."

Schiele controls the arm from the Netherlands as Buzz Aldrin and Brian Cox look on during *Stargazing LIVE* 2015

▼ **It is hoped that this technology will make handling tools easier for astronauts**

Now that both robotics and the computing power needed to control them is finally catching up, the lines between human and robotic exploration are beginning to blur. As the two begin to work closer together the way we explore the Solar System could be in for a big change.

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor, specialising in space science. She gained her PhD in extragalactic astronomy at Cardiff University.

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The Centre for Lifelong Learning at the University of York has just launched its postgraduate diploma in astronomy, delivered online via distance learning and led by Dr Alex Brown. Bringing together students from across the globe to explore the shared wonder of the night sky, the programme will aim to give students a solid foundation of knowledge which will allow them to undertake their own research. We'll explore radio astronomy through the infra-red and into the visible before travelling to ever-increasing energies of radiation to x-rays and gamma-rays, before concluding with neutrino, cosmic ray and gravity wave astronomy – time will also be spent considering the lives and deaths of stars. This exciting two-year, part-time programme starts in late September every year, and is aimed at home astronomers and the academically inclined. Applications are being taken now.

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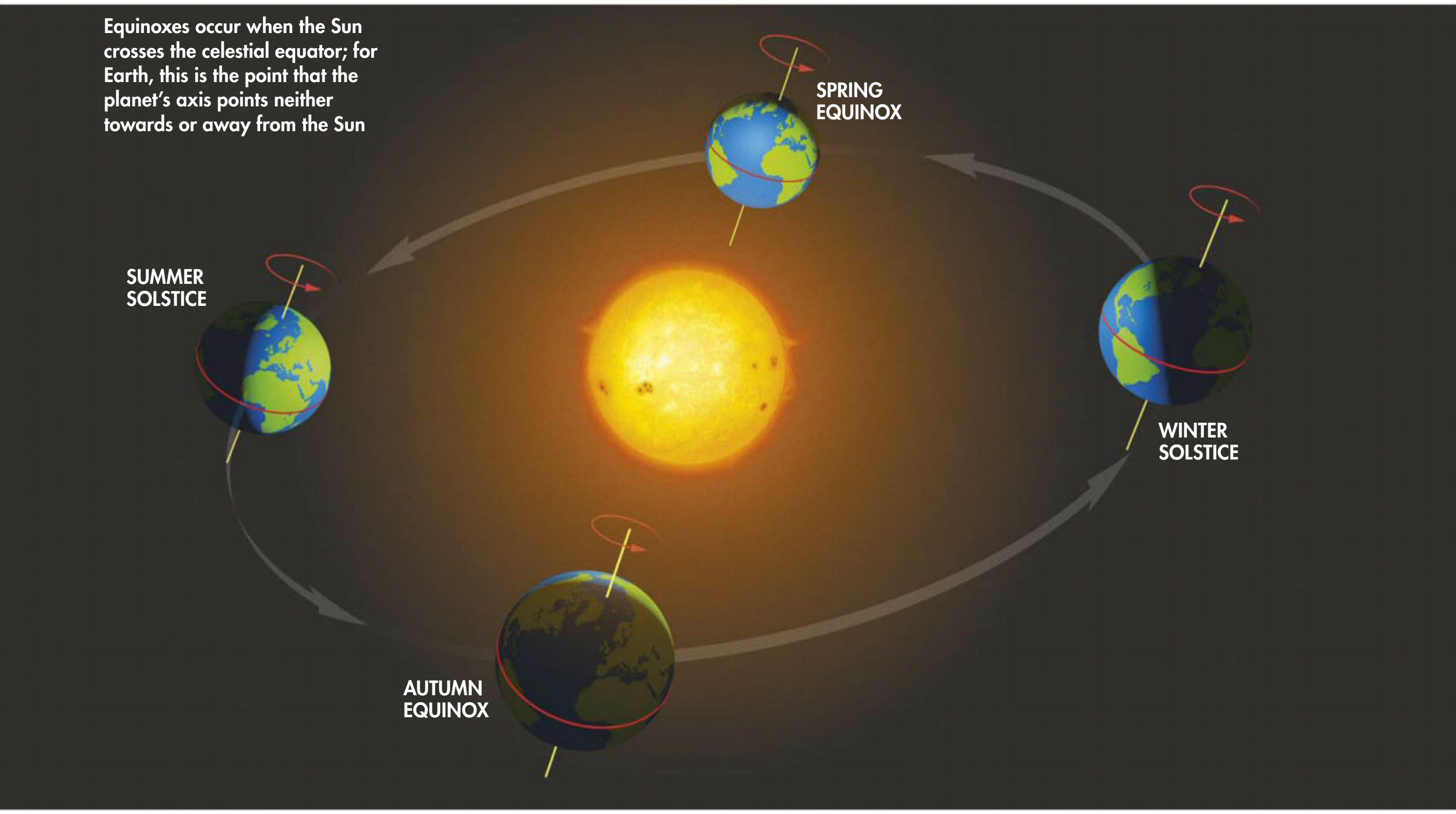
For further enquiries, please contact Romina.Davoudi@nottingham.ac.uk

The Guide

The inequality of equinoxes

With **Olivia Johnson**

Many think day and night are equal on the equinox – but it's a myth



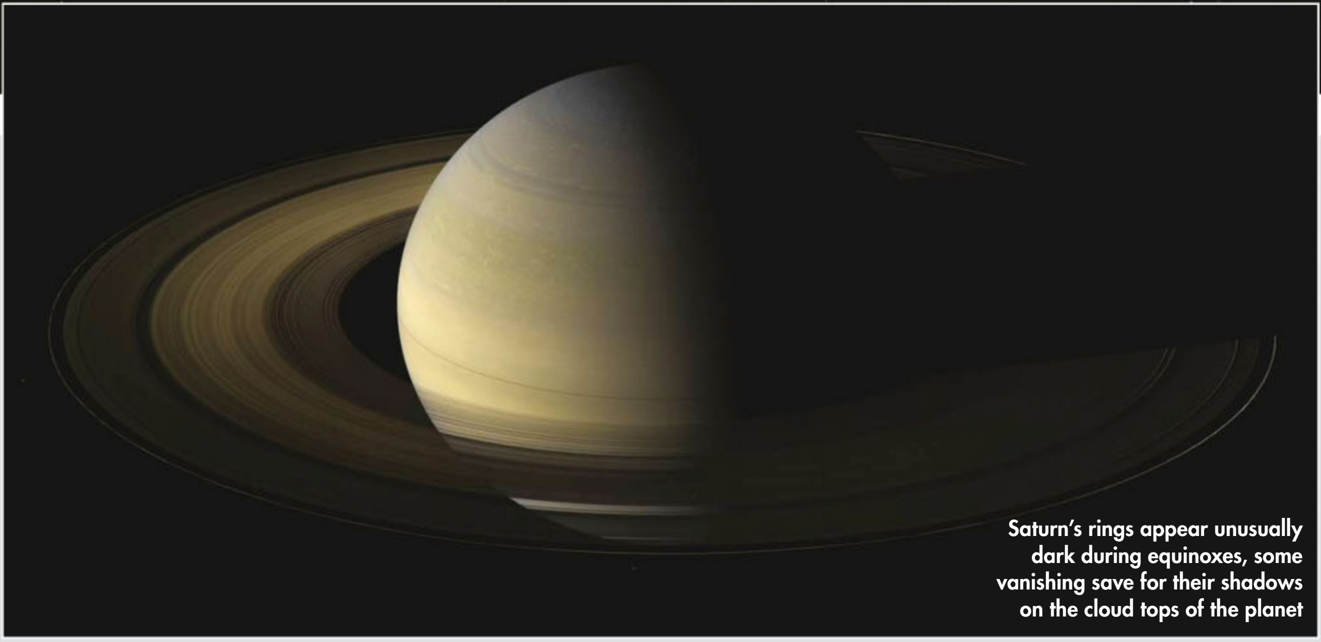
Equinoxes occur when the Sun crosses the celestial equator; for Earth, this is the point that the planet's axis points neither towards or away from the Sun

This month stargazers in the northern hemisphere welcome autumn, with its longer but not yet too chilly nights. Astronomically speaking, the season begins at the September (or southward) equinox, which this year falls on the 23rd; observers in the southern hemisphere mark the advent of spring on this date, which is their vernal rather than autumnal equinox. While it is widely held that night and day are the same length on the date of equinoxes, eager stargazers may be puzzled that daytime outlasts night-time on the 23rd and for several days to follow.

An equinox is one of two moments in a planet's orbit around the Sun when its axis of rotation – in Earth's case, the line connecting the north and south poles – points neither towards nor away from the Sun. The term equinox, derived from the Latin for 'equal night', reflects the fact that on these dates, outside of the polar regions, the Sun will be above the horizon for as long as it is below it. So why the extra daylight, which ranges from a few minutes at the equator to over 20 minutes nearer the poles?

The fact that we consider sunset to be when the last vestige of the solar disc drops below the horizon adds minutes to the day

MARK GARLICK/SCIENCE PHOTO LIBRARY, ISTOCK NASA/JPL/SPACE SCIENCE INSTITUTE, TWILIGHT SUBCATEGORIES: TWCARLISON



Saturn's rings appear unusually dark during equinoxes, some vanishing save for their shadows on the cloud tops of the planet

THE EQUINOXES OF SATURN

Equinoxes aren't just for Earth – all planets with a significantly tilted axis of rotation move through two equinox points as they orbit the Sun. But these moments are particularly spectacular on Saturn, as its brilliant rings seem to disappear! The rings, which are comprised of icy particles orbiting in a thin disc aligned with the planet's equatorial plane, are lit by the Sun throughout the Saturnian year. When the planet reaches equinox, however, the rings are orientated edge-on to the Sun and cast themselves into shadow, vanishing from sight.

Saturn's equinoxes happen once every 14.7 Earth years. Galileo witnessed this rare event in 1612, two years after discovering the rings, and asked, in shock, "Has Saturn swallowed his children?" During the most recent one in 2009, the Cassini spacecraft captured an amazing image of hugely dimmed rings illuminated mainly by sunlight reflected off Saturn. We won't see this phenomenon again until 2024.

Part of the answer is that we see the Sun as a resolved disc measuring 0.5° across rather than as a point source. Astronomical convention defines the sunrise and sunset times as the first and last moments that the solar disc can be seen, rather than when its centre crosses the horizon. Sunrise and sunset are therefore earlier and later, respectively, than the times at which the Sun is aligned with the horizon. This 'extra' daytime is gained twice per day as the 0.25° between the limb and the centre of the Sun rotates through the horizon.

But there's more to it

Daytime is extended even further by the refraction of sunlight in Earth's atmosphere. Refraction is the bending of waves as they travel through materials of different density, as sunlight does when entering our thick atmosphere from interplanetary space. When we view the Sun near the horizon, we see it through a layer of atmosphere that bends its light toward us by a full 0.5°, making it appear higher in the sky than it actually is. This means that at dawn, we see the full disc of the Sun above the horizon when it is still entirely below it! More 'extra' daytime is needed for Earth to rotate through this additional angle.

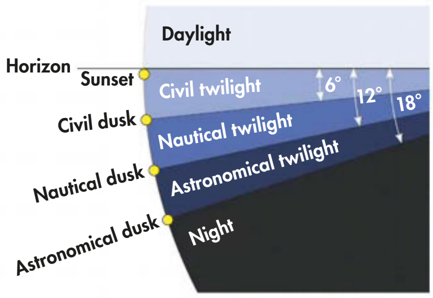
The magnitude of both these effects depends on latitude. At the equator, where the path of the Sun is perpendicular to the horizon, the Sun's apparent motion of 1° every four minutes yields a day that is roughly six minutes longer than the night. Moving closer to the poles, the path of the Sun relative to the horizon is increasingly slanted, so the Sun's apparent motion in the vertical direction is slower and it takes longer to clear the horizon. At 50°N, stargazers face an extra 10 minutes of day before the first night of autumn begins.

Olivia Johnson is an astronomer specialising in science education

TYPES OF TWILIGHT

Atmospheric refraction not only lets us see the Sun's disc before it rises and sets, it also brings sunlight to our skies long before and after the Sun crosses the horizon. The gradual brightening and dimming of our skies before sunrise and after sunset is what we call twilight. It results from both refraction and scattering – absorption and re-emission in a different direction – in the atmosphere.

There are different grades of twilight, depending on how far below the horizon the centre of the Sun's disc is. Down to 6° is civil twilight, when surface objects are still clearly visible in good weather and only the brightest stars and planets can be seen. Down to 12° is nautical twilight, when many stars are visible but the horizon can still be distinguished. Down to 18° is astronomical twilight, when the land is entirely dark and all but extremely faint celestial objects can be observed. Once the Sun is more than 18° below the horizon, the sky is truly dark.



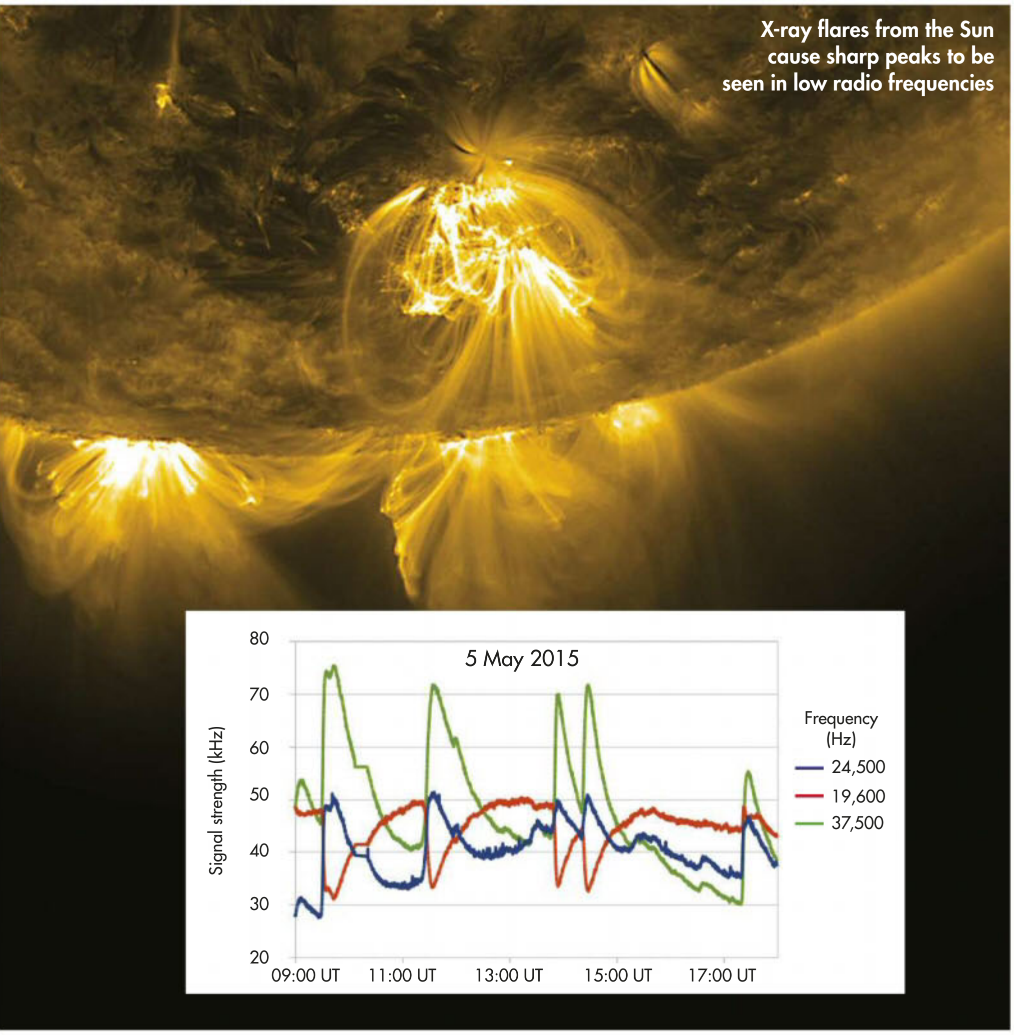
▲ Twilight is split into different grades, but the cause is the same: refraction and scattering

With Paul Hyde

How to

Study ionospheric disturbances

A simple aerial can help you spot X-ray flares on the Sun



X-ray flares from the Sun cause sharp peaks to be seen in low radio frequencies

PAUL HYDE X 2, NASA/SOLAR DYNAMICS OBSERVATORY

TOOLS AND MATERIALS

TOOLS
A small screwdriver and hacksaw for creating the wooden frame.

MATERIALS
A 100m reel of Bell Wire, mono or stereo audio lead with a 3.5mm jack at one end, 5m USB 2.0 extension lead, 4m of 12x32mm (or similar) timber for the frame.

HARDWARE
A computer running Windows XP, 7 or 8 and an external USB sound card.

SOFTWARE
The Spectrum Lab freeware (www.qsl.net/dl4yhf/spectral1.html) and the configuration file included with this month's Project Resources.

Sudden ionospheric disturbances (SIDs) are rapid changes in the Earth's ionosphere caused by X-ray flares erupting on the Sun. These flares release massive amounts of X-ray and ultraviolet radiation and, around eight to nine minutes later, this wall of energy slams into our atmosphere, modifying the way it reflects signals from low-frequency (15 to 30kHz) radio stations. The result is a distinctive 'shark's fin' change in the received signal strength, which reveals that a flare event has occurred.

An SID detector is easy to build, being nothing more than a simple loop aerial connected to the microphone socket of a computer. If this sounds confusing, remember that all a microphone does is convert changes in air pressure (sound waves) into tiny electrical signals that are amplified by the sound card in your computer. In contrast, an aerial converts changes in electromagnetic fields to tiny electrical signals, and at these low frequencies your sound card can act as a perfectly good receiver. Unfortunately, the performance of computer microphones is very variable. There is also a very small risk of damaging the computer from static electricity. An alternative is to use a low-cost external USB sound card.

Fashioning the aerial

Make the aerial from bell wire looped around a few times: the dimensions are not critical but it should be at least $1m^2$. That's quite a size, but it can be hung on the wall of your observatory or in the loft, away from sources of radio interference such as computer monitors and plasma televisions. Larger is always better, even if this means fewer turns of wire, so go for the biggest area you can.

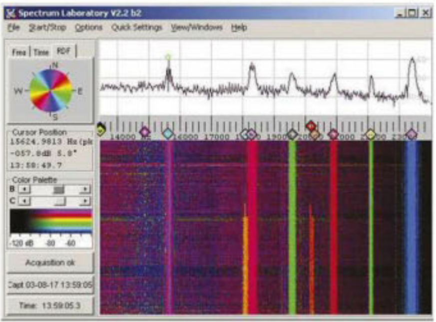
Bell wire consists of two PVC-coated wires, usually with a stripe marking one of the cores. Buy a 100m reel, choosing a product with solid copper wire rather than copper-coated aluminium. Decide on a size for your loop and make a wooden cross to help you wind it. You can then remove the frame if wanted ▸

▸ and simply drape the loop in its final location, or perhaps enclose it in plastic mini trunking for a tidier finish. The loop is directional and the best results will probably be achieved with the winding aligned north to south.

Linking the two

Finally, you will need an audio cable with a standard 3.5mm plug on one end to connect the loop to the microphone socket on the sound card. The easiest solution here is to buy a ready-made cable and cut off the unwanted connector. Plug in the sound card to your computer and wait for any driver installation to complete, then adjust the configuration settings in the Sound tab of Windows' Control Panel. For the final setup, move the sound card to the aerial and use a USB extension cable to connect it to the computer.

The software you'll need to see and record SIDs is Spectrum Lab, available from **www.qsl.net/dl4yhf/spectra1.html**, which is shown below.



Spectrum Lab will run under Windows XP, 7 and 8. Download and install the latest version and then use **File> Load Settings From** to load the RAG_SIDv1.usr configuration file, included in this month's project resources.

Select the external USB sound card as the source using Spectrum Lab's Options and Audio Settings tabs. You should now see several very-low frequency stations appear in the Waterfall window. Then use the View, Watch List and Plotter options to display the Plotter chart, which will reveal the sudden changes in signal levels caused by X-ray flares – a sure sign that it's time to get your solar telescope out.

Paul Hyde is the coordinator of the BAA's radio astronomy group

PROJECT RESOURCES

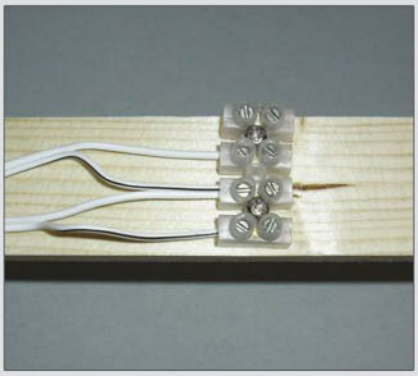
Download the Spectrum Lab configuration files, plus guides to setting it up and interpreting SIDs at **http://bit.ly/howto124**

PAUL HYDE X 6

STEP-BY-STEP GUIDE

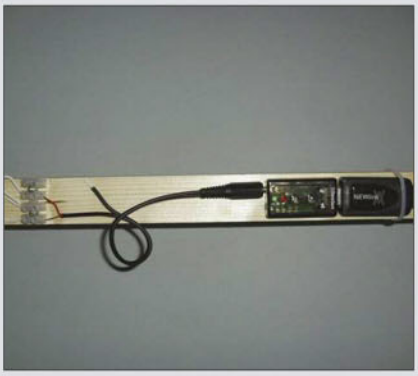
STEP 1

Cut notches at each end of a temporary wooden frame to hold the bell wire in place. Avoid twisting the wire and keep the windings taught, but don't overstretch it. Use tie wraps or insulating tape at 100mm intervals to bundle the wires together.



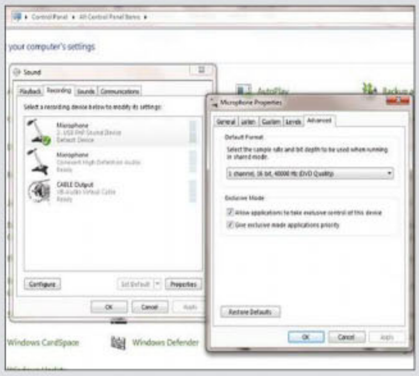
STEP 2

Screw a four-way terminal block to one leg of the wooden frame and connect the bell wire cores so as to create a single, continuous loop. Make sure you connect the wires as shown above or you will lose half your signal.



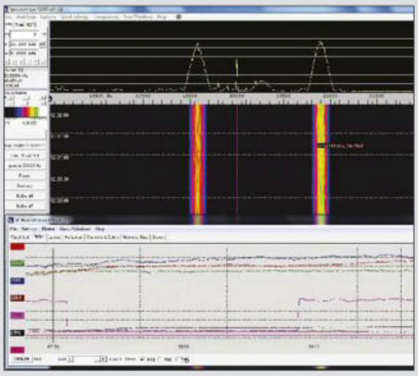
STEP 3

Remove 10cm of insulation from the left-hand channel of the audio lead and connect the centre (red) wire to one end of the loop and the braid to the other. Only add the USB sound card once you have set it up on the computer (Step 4).



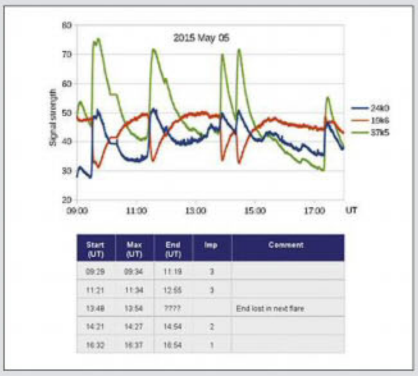
STEP 4

It's better to install the sound card with it plugged into your computer directly. Once done, check its microphone (recording) settings: the Sample Rate should be 48,000Hz or higher, the Level should be set to maximum and AGC switched on.



STEP 5

Install the Spectrum Lab software and adjust the scales for the aerial and sound card as necessary; each will be different. The Plotter window is the one used for day-to-day observing. Adjust each signal to fall two-thirds up the chart by modifying its Watch List entry.



STEP 6

For detailed analysis use a spreadsheet to show the imported daily text files that are saved in the Spectrum Lab system folder. Refer to the files in this month's Project Resources (see left) for advice on how to measure and report SIDs to the BAA.

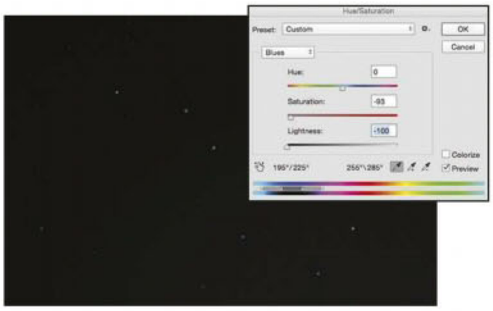
Image processing

Removing unsightly sky glow

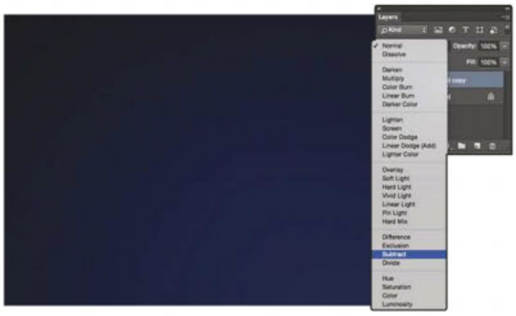
With **Ian Evenden**

In our final shot the stars are clear but the background sky glow is nowhere to be seen

▲ Our starting shot of the Plough asterism is marred by an irritating blue glow



▲ Start by tweaking the Hue/Saturation sliders for the colour causing the cast in your image



▲ Stars blurred out, the remaining pollution can be removed with a Subtract blend

Light pollution is one of the banes of an astrophotographer's life. The glow that creeps into images not taken under perfect viewing conditions only gets worse with longer exposures, and pollution invisible to the naked eye can make itself known if you leave the shutter open long enough.

Image-editing programs offer a couple of ways to remove the light pollution. These are not magic wands that can make images perfect in just a few clicks, and detail smeared beyond recognition by light pollution will not snap back into focus, but nonetheless it may surprise you how much you can rescue an image.

For this tutorial we're using an image of the Plough, which is circumpolar in the northern hemisphere, taken a little too close both to sunset and an airport. It suffers from a blue glow rather than the orange that's frequently produced by street lighting, but the process for removing it remains the same.

Once you've got the image open in your editing software, your first port of call is the Hue/Saturation tool (**Image** > **Adjustments** > **Hue/Saturation**). In the floating palette that appears, use the drop-down menu to select the colour range you want to work with – it would be yellows if your sky glow were somewhat banana-coloured, but in our case its blue. Experiment with dragging the saturation and lightness sliders to the left. This can remove a surprising amount of light pollution so long as there aren't multiple colours to deal with, but this has the downside of removing any colour you've captured in the stars themselves.

To avoid this, you can do something clever with layers. In the Layers palette, duplicate the background layer (**Right click** > **Duplicate Layer**) and make sure the new layer is in front of the original by putting it above the original in the palette's stacking order. It usually goes there by default. Completely blur this new layer until no stars are visible using Gaussian Blur (**Filter** > **Blur** > **Gaussian Blur**). In the floating palette that appears, set the radius to about 50 pixels – you want to make sure the star detail is completely gone. Click OK, and you'll be presented with a very smooth, averaged version of your scene, approximately the same colour as the light pollution you're trying to remove.

We're going to blend the layers using the Subtract blend mode, which can be selected from the drop-down menu on the Layers palette. Subtract is a simple bit of arithmetic that subtracts the numerical colour values of one layer from those underneath, displaying black if it returns a zero. As we averaged out the top layer using the blur, the background becomes black while the stars retain their colour, and become even easier to see on the new dark background.

If you find the black a little too stark, experiment with the opacity of the top layer using the slider on the Layers palette (it's next to the blend modes) to bring back a touch of colour. This is also an opportunity to tinker further with the image by running a Levels adjustment on the background layer to enhance the stars further. Doing this to our Plough image brings out a yellow colour from the star Dubhe (Alpha Ursae Majoris) on the right of the Plough's 'bowl'. Once you're happy, flatten the image from the Layers menu and save as a new file.

Ian Evenden is a journalist working in the fields of science, tech and photography

ALL PICTURES: IAN EVENDEN

Scope DOCTOR

With **Steve Richards**

Our resident equipment specialist cures your optical ailments and technical maladies

One low-tech way of adding stability is to tie a bag of rocks to your tripod

My motorised telesecope's thin aluminium tripod vibrates a lot; is there anything that I can do to stabilise it?

DOMINIC BURGESS

Vibration is an all too common problem in the quest for lightweight, portable equipment, but it can be very frustrating when carrying out tasks such as focusing. Whenever we review mounts, this is one of our most important tests.

There are various components that contribute to the vibration problem: there's the tripod itself, but the mount and the parts that attach the telescope to the mount contribute too. It is important to ensure that all the retaining bolts for the mount and scope are tight, and you should also look over the tripod to check that all the fittings that hold the tripod body to the legs are secure. Always insert the leg brace if your tripod has one, as this makes a significant improvement to stability, and try not to extend the legs any further than absolutely necessary.

Quite often, the extending part of the leg is a pretty loose fit between the outer support struts, but applying a thin strip of self-adhesive Teflon tape to one side can close the gap while still retain freedom to extend the leg.

A great improvement can be gained by suspending a bag containing stones or sand underneath the centre of the tripod so that it just touches the ground to avoid any swing.

Finally, set up on grass rather than a patio wherever possible, as this softer surface helps to absorb the vibrations.

STEVE RICHARDS, PAUL WHITFIELD

STEVE'S TOP TIP

How do dark frames improve astrophotos?

All digital camera sensors generate thermal 'noise' and hot pixels when capturing long-exposure images. Camera cooling systems can help to reduce this, but there is also a very useful calibration tool that can counter hot pixels and general thermal noise called a dark frame. This is simply an image taken at the same exposure length as the main image, but with the telescope capped. By doing this, the dark frame captures just the thermal noise generated by the sensor. You can subtract this noise data from the main image in post-processing, often delivering a good improvement in image quality.

My EQ5 SynScan computerised Go-To mount is set up for use in North America; how can I change this so it works in the UK?

DEREK RIGSBY

▲ SynScan-controlled mounts can only guide you after you've set your location

A Go-To mount certainly won't work correctly straight out of the box as there are various parameters that must be set correctly before you can get going. The mount must first of all have its location in latitude and longitude set – be sure to get these the right way round and entered as degrees and minutes, not as decimal degrees. In the UK, you should set your latitude as north (N) and longitude as either east (E) or west (W) of the Greenwich Meridian, information that can be conveniently found at **www.satsig.net/maps/lat-long-finder.htm**.

You must then set the time zone correctly; for the UK this is +00:00. Next, set the date remembering this will be in American format (mm/dd/yyyy), which can trip people up! Next, the local time must be set in 24-hour format and finally you must indicate if the entered time is daylight saving (BST) or GMT by selecting 'Y' for the former or 'N' for the latter.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

- ★★★★★ Outstanding
- ★★★★☆ Very good
- ★★★☆☆ Good
- ★★☆☆☆ Average
- ★☆☆☆☆ Poor/Avoid

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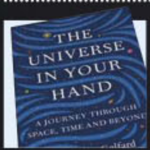
This month's reviews

Tried & tested

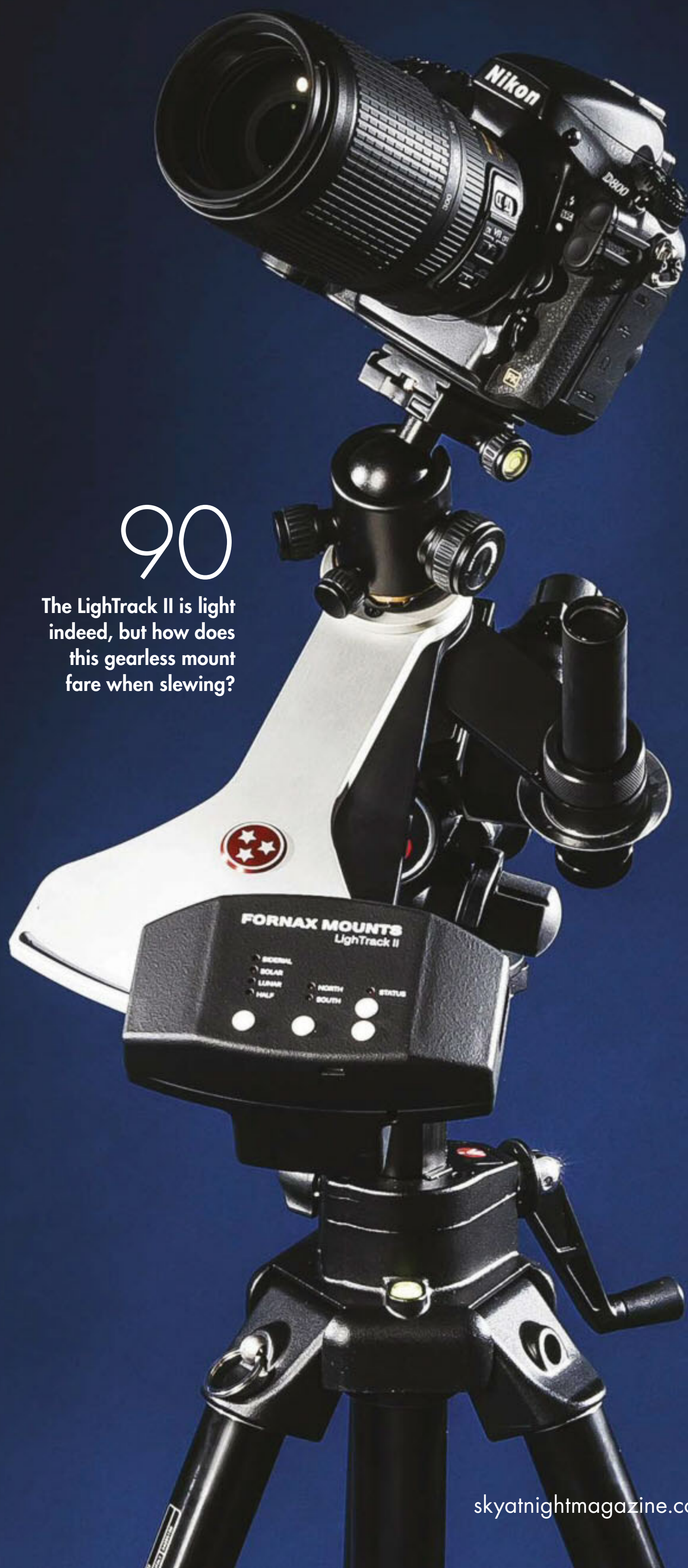
First light

Books



Gear

Find out more about how we review equipment at: **www.skyatnightmagazine.com/scoring-categories**



90

The LighTrack II is light indeed, but how does this gearless mount fare when slewing?

WWW.THESECRETSTUDIO.NET X 4

TRIED & tested

We review well-established equipment that's stood the test of time

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/SkyMax180**

VITAL STATS

- **Price** £829
- **Optics** Maksutov-Cassegrain
- **Aperture** 180mm (7.1 inches)
- **Focal length** 2,700mm (f/15)
- **Weight:** 7.8kgs
- **Focuser** Movable primary mirror via rear knob
- **Extras** 9x50 finderscope, 2-inch fit star diagonal, 2-inch to 1.25-inch adaptor, 2-inch, 28mm long eye relief eyepiece, Vixen-style mounting bar
- **Supplier** Optical Vision
- **www**.opticalvision.co.uk
- **Tel** 01359 244 200

SKY SAYS...
This instrument is not just good for visual observing, but also capable of deep-sky astro imaging

WWW.THESECRETSTUDIO.NET X 3,DAVE ARMESON

Sky-Watcher SkyMax 180 Pro Maksutov-Cassegrain

The portable 'planet killer' that offers decent deep-sky views too

WORDS: PAUL MONEY

Maksutov-Cassegrain telescopes employ mirrors and a front corrector lens to produce a compact, quite portable optical tube. This form of optical arrangement makes this a catadioptric or compound telescope. The SkyMax 180 Pro is the largest in the Sky-Watcher range, yet despite its seemingly modest 7-inch mirror it punches above its weight.

Early models were painted gold and white, and were supplied with two 1.25-inch eyepieces and a straight-through finder. For the SkyMax 180 Pro, Sky-Watcher has altered the colour scheme to a fetching black on diamond effect, updated the glass in the optics, changed the finder to a 9x50 right-angled variant and now only supplies one eyepiece, a 28mm long eye relief model with twist-up eyecup – however, the review scope was supplied with two 1.25 inch eyepieces (20mm and 9mm). Completing the package is a star diagonal and a Vixen-style mounting bar.

Since 2008, Sky-Watcher has used Schott optical glass in its higher-end Pro series telescopes, and it is used again in the SkyMax 180 Pro. The secondary mirror is integrated into the front corrector plate and produces a smaller secondary obstruction compared with some similar sized telescopes.

The focal length of 2,700mm folds into a tube only 500mm long (though there is a back tube extension of 60mm). Along with a tube width of 216mm, it really is quite compact. At just 7.8kg too, it is also relatively lightweight for its size. Our EQ5 SynScan mount could handle it, but we found the larger NEQ6 mount offered the best performance.

Finding our way

The long focal length is ideal for planetary and lunar viewing, but this instrument also gives good views of many deep-sky objects. The right-angled finderscope gives a 9x magnified view of the sky and many of the brighter deep-sky objects are visible in it, making locating them and finding alignment stars that much easier.

Using the 20mm eyepiece we checked the field of view for quality and were rewarded with a sharp view of the bright star Altair (Alpha Aquilae) across almost 90 per cent of the view, with only the slightest distortion in the star visible at the edges. Turning our sights farther afield, we enjoyed very good views of several popular targets such as the Dumbbell Nebula in Vulpecula, The Ring Nebula in Lyra and open cluster M39 in Cygnus – the latter more than filled the field of view the 20mm eyepiece gave. ▸

OWNER'S OBSERVATIONS

Name Dave Armeson
Location Hull, East Yorkshire
Equipment SkyMax 180 Pro with Moonlite focuser
Owner since April 2013

I have been simply amazed by this scope. It will easily outperform a good quality 5-inch apo refractor when imaging the Moon and planets with its light grasp and resolving power. Even the views of compact deep-sky objects are brilliant, showing loads of detail with superb contrast. On the Moon, minute detail is visible, whilst Saturn is stunning with belts, zones and subtle structure in the rings. I call the scope my 'planet killer'! The best single upgrade I have made to the telescope was to add a Moonlite focuser. This has made a great telescope into an amazing one, as I take high-resolution lunar images and the focuser makes this a breeze to achieve, critical focus is important.

After 30 years of astronomy I have reached my telescope nirvana after having some excellent scopes over the years. The SkyMax 180 Pro is a very powerful scope, not just in magnification but in its overall performance. Mine has caused such a stir at The York Astronomical Society three people have gone out and bought one.

OPTICS

The optical configuration is of a spherical primary mirror at the back with a corrector plate at the front, which also has a secondary silvered 'spot' on the convex side of the corrector. Sky-Watcher uses Schott glass for the optical elements and high-transmission multicoatings on all optical surfaces.

COMPACT BODY

The body weighs 7.8kg, while the optical design folds the light path to deliver a 2,700mm focal length in a tube just 500mm long. It attaches to a mount via a Vixen-style dovetail bar.

EYEPIECE AND STAR DIAGONAL

The SkyMax 180 Pro is supplied with a 2-inch-fit star diagonal with a 2-inch to 1.25-inch adaptor. Though our review scope was supplied with 20mm and 9mm 1.25-inch eyepieces, in the future this instrument will be packaged with a single 28mm 2-inch LET (long-eye relief, twist-up eyecup) eyepiece.

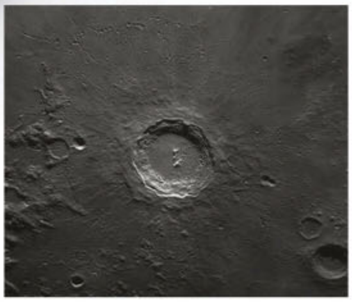
TRIED & tested

FINDER

The original finder supplied with gold-coloured SkyMax 180 Pro was a straight-through variant. This has been replaced with a 9x50 right-angled view finderscope, which is far more user friendly and easily adjustable to line up with the main optical axis.

FOCUSER

The focuser takes the form of a rotatable knob located at the back of the telescope. The mechanism was smooth in operation and had plenty of range to accommodate a star diagonal and eyepieces, but there was a little play in the system.



▼ Crater Copernicus, stacked from 3,000 frames captured with the SkyMax 180 and a ZWO ASI120MM camera

▼ The Crab Nebula imaged with the SkyMax 180 and a modded Canon EOS 300D DSLR

▸ Globular cluster M13 in Hercules was impressive, with multitudes of stars crowding its centre and the famous dark feature known as the Propeller easily visible. The double star Albireo (Beta Cygni) was a treat with its golden yellow primary and pale sky-blue companion in the 20mm eyepiece, while with the 9mm eyepiece we were able to split the tight triple star Iota Cassiopeiae before morning twilight overcame it.

Saturn was lovely, with the Cassini Division, a dusky band on the disc and a polar region all on show. We also saw several of the brighter moons in spite of the planet's low declination by swapping in our own 26mm 1.25-inch eyepiece and boosting magnification with a 3x Barlow lens. In our Owner's Observations, Dave Armeson calls the SkyMax 180 Pro a 'planet killer' – we couldn't agree more considering the price of the system compared with other telescopes of similar apertures.

Attaching our own DSLR, we captured views of the Moon and could take long, tracked exposures of a number of deep-sky objects, revealing this instrument is not just good for visual observing, but also capable of deep-sky astrophotography. We expect this telescope will be around for a good few years yet. S

SKY SAYS...
Now add these:
1. HEQ5 Pro SynScan mount
2. HyperFlex-7E2 9-27mm 1.25-inch zoom eyepiece
3. Lunar and planetary filter set

VERDICT

BUILD AND DESIGN	★★★★☆
EASE OF USE	★★★★☆
FEATURES	★★★★☆
IMAGING QUALITY	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★☆

WWW.THESECRETSTUDIO.NET, PAUL MONEY, DAVE ARMESON

FIRST **light**

See an interactive 360° model of this mount at
www.skyatnightmagazine.com/LightrackII

Fornax 10 LighTrack II mobile tracking mount

Light by name and light by nature, this mount is great for astronomy on the go

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £399.99
- **Payload capacity** <5kg
- **Latitude adjustment** Adjustable wedge required
- **Tracking rates** Sidereal, 0.5x sidereal, solar and lunar
- **Power requirements** 12V DC
- **Autoguider port** ST-4 (non-standard connector)
- **Extras** DC adaptor, polarscope collar
- **Weight** 1.28kg
- **Supplier** 365Astronomy
- **www.365astronomy.com**
- **Tel** 020 3384 5187

WWW.THESECRETSTUDIO.NET X 5

The quest for accurate but portable tracking mounts suitable for imaging from remote locations or while on holiday produces an increasingly unusual range of solutions. Hungarian manufacturer Fornax's latest builds on the quirky Fornax 10 LighTrack mount, reviewed in the April 2012 issue. The LighTrack II is a much more accomplished product, having shed its original 'prototype' feel for a sleek and elegant construction.

Finished in an attractive satin silver with black trim, the LighTrack II has a high quality and substantial feel, but is both compact at 280mm in length and light at 1.28kg. The simple design has a good tactile feel and the control panel is ergonomically placed for simple operation.

It should be noted that – in common with other portable tracking mounts – you will need to budget for the necessary additional components that will be required to operate the system, these being a tripod, a ball and socket head (to attach equipment), a polarscope and an adjustable wedge (both needed to achieve polar alignment).

We used our own Manfrotto 132 tripod during the review period. It is important that the mount is polar aligned at the start of an imaging session so we used our own Manfrotto 410 geared head, which made adjustment quick and simple. For the purposes of this review, 365Astronomy lent us an EQ5 polarscope and a ball and socket head to test the mount.

SKY SAYS...
The LighTrack II would make an excellent travelling companion with a DSLR and a couple of lenses

Setting up is straightforward and once the mount is attached and roughly set at the correct altitude, the polarscope arm can be swung out and the polarscope attached using the supplied collar. We used a phone app to discover the position of Polaris with regard to the north celestial pole, mirrored this in the polarscope eyepiece and finely adjusted the mount position until the position of Polaris in the polarscope view matched. Finally, we attached a DSLR camera to the ball and socket head, and pointed at our chosen object. We powered the mount from the supplied DC adaptor.

The symphony of the night

During tracking, the mount's electronics produce an almost musical rising and falling tone when driving the quadrant arm, but this is a very subdued sound. Soon we got used to it, realising that it served as a useful indicator that tracking was progressing correctly. A few seconds before the arm reaches the end of its travel, a status light flashes as a warning that a 'rewind' is necessary. Pressing and holding the rewind button causes the arm to move back to its start position in readiness for the next cycle, at which point it is necessary to reposition the camera and telescope or lens to point at the original target again. ►

A MOUNT WITHOUT GEARS

The vast majority of driven mounts use a worm gear to give a large torque but very low rotational speed, with typical amateur astronomy worm gears completing one revolution every eight minutes or so. Despite these advantages, there are disadvantages too in the form of periodic error introduced by minor tolerance errors in the meshing of the gears, which cause the mount to speed up and slow down minutely during the course of a cycle or 'period'. The requirement for lubrication in the form of grease introduces some backlash as well.

The LighTrack II dispenses with a geared system and uses a friction drive instead. The drive system comprises a motor and spindle that drives against the flat edge of a quadrant shaped plate that forms a small section of a virtual circle. With no gears to mesh and no grease to compress, a friction drive can be produced that achieves very smooth tracking. Our tests indicated that the mount could track for one hour and 48 minutes at sidereal rate before requiring a 'rewind' to the start position, which took just 12 seconds to complete.

BUILT-IN CONTROLS

The instrument panel is neatly displayed on the front of the mount and has simple buttons and LED indicators for each function. The four tracking rates are sidereal, lunar, solar and half-sidereal, and these can be used in both the northern and southern hemispheres. There are also two buttons for resetting the quadrant.

CONNECTIONS

The mount has an absolute minimum of connections, making it very quick to set up. A 12V power socket that can be fed from a portable battery or the supplied DC mains adaptor is accompanied by a non-standard connection for autoguiding. This supports the industry standard ST-4 protocol but requires a custom lead.

CAMERA MOUNT

There is no declination axis on a tracking mount like this, so the telescope or camera has to be attached to an adaptor that allows the imaging system to be pointed anywhere in the sky. The simplest method is to use an adjustable ball and socket head that fixes to the tripod bolt on the top of the mount.

TRIPOD, BALL AND SOCKET HEAD, POLARSCOPE AND DSLR NOT INCLUDED

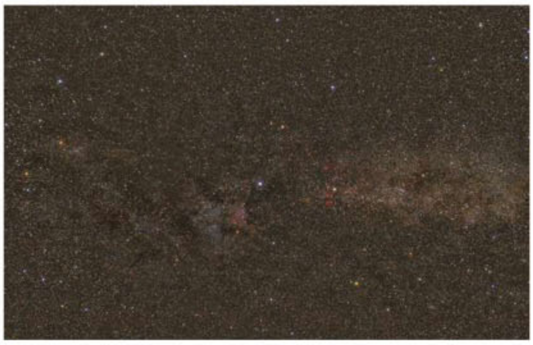
FIRST light

TRIPOD MOUNTING

On the apex of the mount's rear is a 3/8"-16 UNC-threaded hole with a standard 1/4"-20 UNC insert adaptor. This allows the LighTrack II to be attached to a range of different tripod heads; we used a Manfrotto 410 geared head, which allowed us to adjust the altitude for polar alignment.

POLARSCOPE MOUNTING ARM

As with any equatorial tracking device, an accurate polar alignment is vital to avoid trailed stars and field rotation. The LighTrack II has a substantial polarscope arm that swings out, allowing for the insertion of a standard EQ5 polarscope. No polarscope is supplied.



▲ **Cygnus captured with a Canon EOS 450D DSLR and 28mm lens; the image is a trio of three-minute exposures**

▲ **A 1.3-second exposure of the Moon, Venus and Jupiter with a Canon EOS 450D DSLR using half-sidereal tracking**

▸ The default tracking rate is sidereal, but there is a simple selector button to switch to one of the other speeds – solar, lunar and 'half' (0.5x sidereal). Solar and lunar are self-explanatory, while the half rate is a pleasant extra that aids in the photographing of celestial scenes that incorporate grounded objects such as trees and buildings. This is achieved by running the mount at half-sidereal rate so that although the stars will trail somewhat, the surrounding countryside won't be as blurred as it would be at full sidereal rate, giving a good compromise. This rate can also be used to capture interesting timelapse terrestrial images by setting the mount in a horizontal position.

The tiniest trails

The mount performed well during our tests despite pretty poor skies and very short nights. Our three-minute exposures taken through a 200mm telephoto lens exhibited a small amount of star trailing, but this was only really visible when images were examined on a computer at full size. Images with shorter focal length lenses showed no trailing. There were no large excursions in the tracking and each image was of a similar quality.

The LighTrack II would make an excellent travelling companion with a DSLR camera and a couple of lenses. Its simplicity makes it suitable for beginners, although no instruction manual is included. Ⓢ

VERDICT

ASSEMBLY	★★★☆☆
BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★☆
FEATURES	★★★★☆
TRACKING ACCURACY	★★★★☆
OVERALL	★★★★☆

SKY SAYS...
Now add these:

1. Tele-Optic mini wedge
2. 365Astronomy heavy-duty ball head
3. Sky-Watcher EQ5 polarscope

WWW.THESECRETSTUDIO.NET X 2, STEVE RICHARDS X 2

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Sky at Night MAGAZINE REVIEWED IN ISSUE 110 JULY 2014
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Telescope House, Unit 1 Starborough Farm, Starborough Rd, Marsh Green, Kent, TN8 5RB
All prices correct at time of press. Subject to change. Errors and omissions excepted.

FIRST **light**

See an interactive 360° model of this camera at
www.skyatnightmagazine.com/ASI034MC

ZWO ASI034MC colour USB 2.0 camera

A low-cost camera that will get you off to a great start in Solar System imaging

WORDS: MARTIN LEWIS

VITAL STATS

- **Price** £118.80
- **Sensor** 0.25-inch Colour Aptina CMOS ASX340CS,
- **Pixels** 728x512 pixels (5.6μm across)
- **Size** 62mm diameter, 28mm long without nosepiece
- **Connections** USB 2.0
- **Weight** 110g
- **Extras** 1.25-inch nosepiece, USB 2.0 lead, software CD
- **Supplier** 365Astronomy
- **www.**365astronomy.com
- **Tel** 020 3384 5187

WWW.THESECRETSTUDIO.NET X 5

ZWO was founded only four years ago but already sells a wide range of digital video cameras manufactured in-house, all designed for astronomical use and particularly the imaging of Solar System objects. The ASI034MC is its entry-level USB 2.0 digital imaging camera, boasting high sensitivity and high speed in a low-cost colour camera package.

Digital video cameras such as the ASI034MC enable you to capture a stream of short-exposure frames of bright objects, which – using free software such as RegiStax or AutoStakkert! – you can then sort through, select and stack the best frames to create an averaged image relatively unaffected by the turbulence in Earth's atmosphere.

Before connecting the camera to your computer for the first time, you need to install a driver. This is supplied on a CD that also contains a primitive interface program called AMCap; ZWO itself suggests using the much better freeware programs SharpCap or FireCapture for camera control. These programs allow you to control the exposure, gain, colour balance, format and many other camera settings.

We tested the camera with FireCapture, a popular feature-rich program specifically designed for a selection of common astronomy-related digital video cameras, including the full range of ZWO devices. Like the ZWO cameras, FireCapture is a product designed by astronomers for astronomers, and it is being continually improved and enriched. Online tutorials are available to help you get up to speed with the program if you are unfamiliar with it. In all of our tests, the camera gave no issues when driven with the latest version FireCapture running on an old Windows XP laptop.

SKY SAYS...
The ASI034MC is a tremendous value camera with astonishing performance for the price

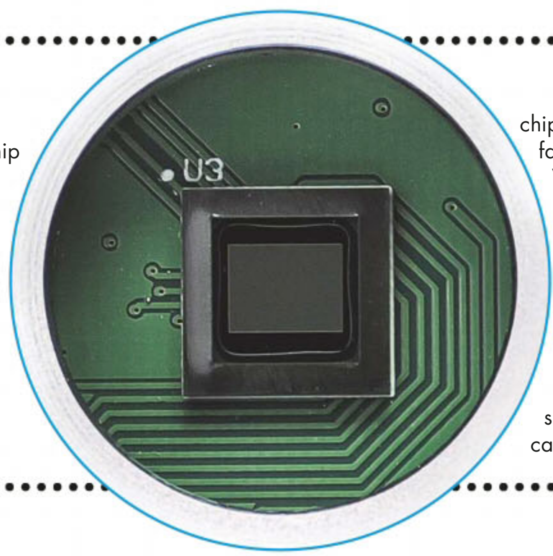
Framing the night

We connected the camera to a 8.75-inch Newtonian scope and – using a Barlow lens to boost the image scale – we captured the planets Venus and Jupiter in bright twilight. We were impressed by the camera's high speed when not limited by the exposure time. The interface is USB 2.0 rather than USB 3.0, but despite this we achieved frame rates of 75fps (frames per second) at full frame. With a reduced frame size, known as 'region of interest' setting, the frame rate can be pushed higher, rising to 260fps for a frame size of 320x240 pixels.

A quarter Moon hanging high in the southern sky was our next target. The ASI034MC has a chip size of 728x512 pixels and it is generally recommended to have a larger chip than this with more pixels when imaging the Moon or Sun; even so the camera ▸

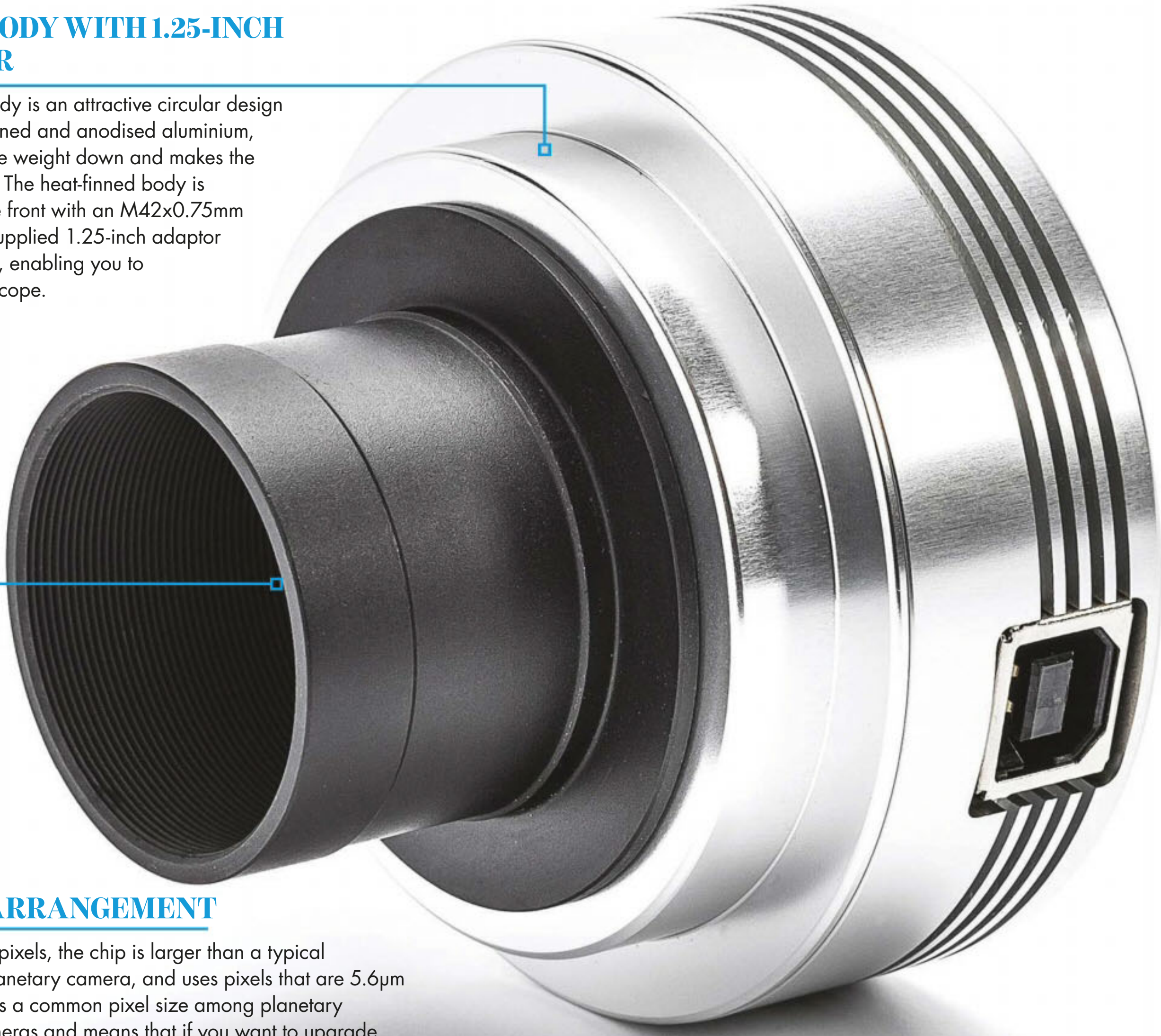
CMOS OVER CCD

Unlike many competing planetary cameras, ZWO's ASI034MC uses an Aptina CMOS chip rather than a more common CCD chip. CMOS chips used to be the noisier and less-sensitive cousins of CCDs, but recent improvements in technology have advanced CMOS chips to the point where their noise and sensitivity levels can be comparable or even better than CCDs. In addition CMOS chips are faster and cheaper to make than CCDs and usually run at lower power consumption. Cameras based on the sensitive Sony ICX618 CCD chip were – until recently – the most favoured ones for Solar System imaging. We found the ASI034MC's noise levels and sensitivity similar to that of ICX618-based colour cameras. We also found its speed similar or better than USB 2.0 cameras using that chip, especially as the ASI034MC has the ability to reduce the frame size to increase the frame rate further. For the ASI034MC it is the low price for such a well-performing Solar System camera that is the real stand-out feature.



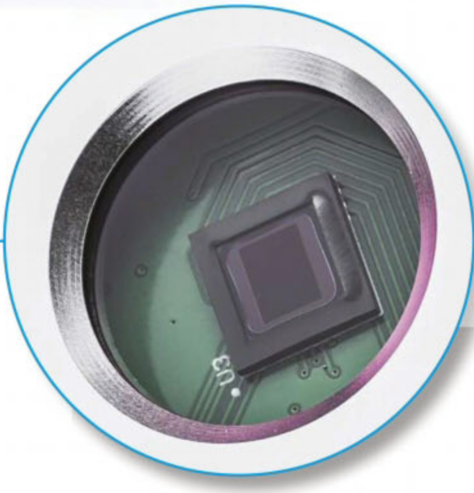
METAL BODY WITH 1.25-INCH ADAPTOR

The camera body is an attractive circular design made of machined and anodised aluminium, which keeps the weight down and makes the camera robust. The heat-finned body is threaded at the front with an M42x0.75mm T-thread. The supplied 1.25-inch adaptor screws into this, enabling you to connect a telescope.



PIXEL ARRANGEMENT

At 728x512 pixels, the chip is larger than a typical 640x480 planetary camera, and uses pixels that are 5.6μm across. This is a common pixel size among planetary imaging cameras and means that if you want to upgrade the camera at a later date you can use your same Barlow lens without the image scale changing.



INFRARED/ULTRAVIOLET FILTER COVERGLASS

The camera has an infrared/ultraviolet-blocking filter fitted just in front of the chip, which is useful for a colour camera as it helps to improve image detail. The fact that it is built-in saves you having to buy a separate filter. It also protects the chip from dust and dirt.

FIRST light

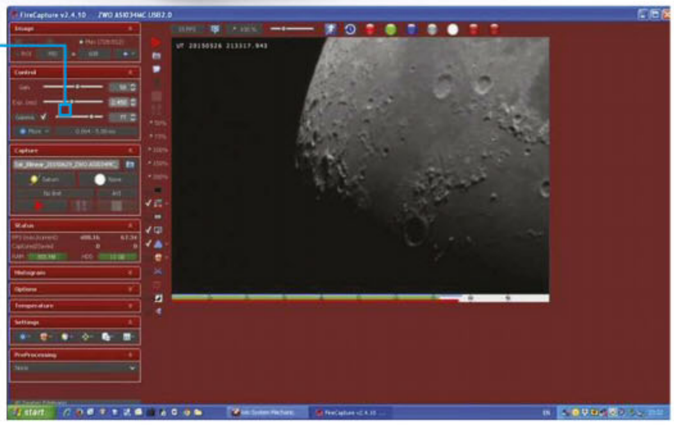
COLOUR CHIP

A colour chip is ideal for those starting out with planetary imaging as you don't need to buy separate red, green and blue filters and take separate videos through them. This keeps the cost down and makes the task of taking images and post-processing much simpler and quicker.

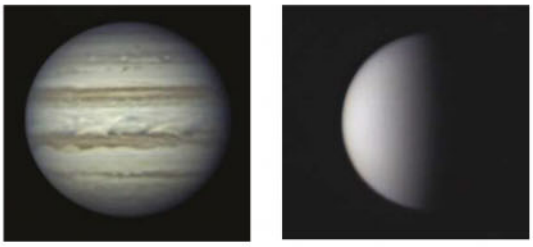
SKY SAYS…
Now add these:
1. ZWO five-position filter wheel with 1.25-inch eyepiece holder
2. ZWO 1.25-inch CCD LRGB filter set
3. ZWO 60mm finder and guidescope with non-rotating helical focuser

GAMMA CONTROL

The ability to set the camera gamma, often absent in commercially available digital video cameras, is a welcome feature in the ASI034MC. This allowed us to drop the contrast when imaging the Moon, enabling us to capture details in darker lunar areas without burning out adjacent brighter areas.



▸ Saturn stacked from a 60-millisecond exposure at 16fps



▸ Right: Jupiter stacked from a 26-millisecond exposure at 37fps; far right: Venus from a 0.7-millisecond exposure at 75fps

The Mare Imbrium, captured via a 2.5-millisecond exposure with gamma at 77

▸ performed well and we got some nice smooth lunar images that showed plenty of detail at the terminator. We used the camera's gamma adjustment to good effect here, enabling us to cope with the large brightness range for different features at the terminator.

Saturn was our final object to image but this was low in the south even at its highest altitude; it is always a tough planet to successfully image due to its low surface brightness. Low surface brightness requires longer exposures and this often leads to significant blurring by the atmosphere, especially at low altitude. Although a relatively sensitive camera, we had to push the gain up a bit higher than for other targets to keep the exposure times reasonable. At these higher gains we started to notice increased levels of noise in this camera compared to ZWO's more advanced models. As a result, longer runs were needed to gather more frames allowing us bring the noise down to acceptable levels and generate a good image.

The ASI034MC is a tremendous value colour planetary imaging camera with astonishing performance for the price. If you want a low-cost camera to get you started with Solar System imaging then it comes highly recommended. Ⓢ

VERDICT

BUILD & DESIGN	★★★★★
CONNECTIVITY	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★★
IMAGING QUALITY	★★★★☆
OVERALL	★★★★★

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Books

New astronomy and space titles reviewed

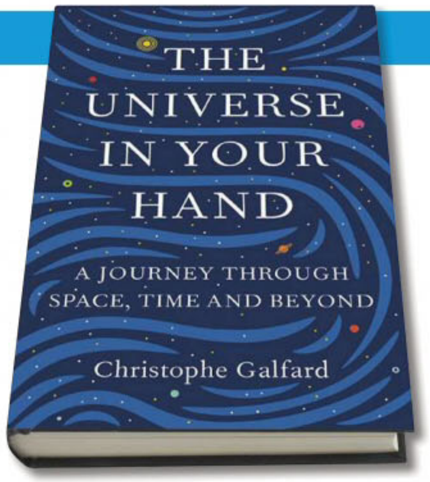
RATINGS
★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

You can order these books from our shop by calling 01803 865913

The Universe in Your Hand

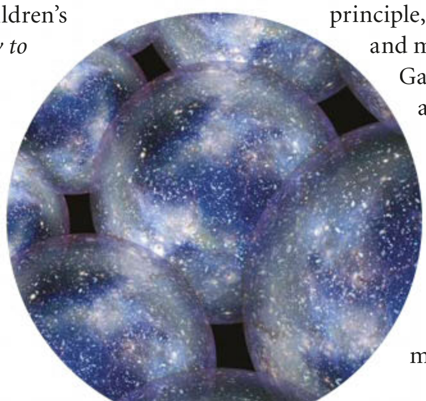
A Journey Through Space, Time and Beyond

Christophe Galfard
Macmillan
£14.99 ● HB



Can non-scientists grasp cosmology, general relativity and quantum field theory? French-born theoretical physicist and writer Christophe Galfard certainly believes so. In *The Universe in Your Hand* he comes a long way to achieving that goal, but this book may not satisfy everyone.

Galfard contributed to Stephen and Lucy Hawking's children's book *George's Secret Key to the Universe* and its two sequels. His latest book covers more or less similar ground, but is not specifically aimed at children – the blurb on the book's back cover says it's for readers of all ages. However, it's hard to understand which knowledge-hungry adults would really like the book's approach.



The theory of multiverses suggests that our reality might be just one of many

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY

Within is a lengthy series of imaginary trips through space, time, atoms and even into a black hole, but many of those fictional stories aren't really helpful in getting the message across and may actually distract from the real content of the book.

Repeatedly turning back to the same tropical beach, the same airliner or the same Australian great-aunt with her ugly crystal vases doesn't help the book either – the narrative is a bit unbalanced and lacks real tension. And Galfard's returning argument that science will enable humanity to survive the death of the Sun appears to be quite silly, to say the least.

Nevertheless, it certainly provides a very clear introduction to such arcane topics as cosmic expansion, the uncertainty principle, quantum tunneling and multiple universes. Galfard successfully anticipates most of the questions that will pop up in the reader's mind, and his use of many short sentences ("So far so good", "Sounds fair?" "Strange") makes for easy reading.

So is this a book for you? Maybe. If you had trouble digesting books like those of *The Elegant Universe*, *The Fabric of the Cosmos*, or *The Hidden Reality* by American physics writer Brian Greene, Galfard's new book may provide an easier introduction to cosmology, quantum physics and the multiverse. But after you've read *The Universe in Your Hand*, I would certainly suggest giving those other books a second chance.

★★★☆☆

GOVERT SCHILLING *is an astronomy writer and author*

TWO MINUTES WITH CHRISTOPHE GALFARD

What inspired you to write the book?

As a teenager I began to try and understand our reality using the most powerful tool we have: science. A few years later Stephen Hawking offered me the chance to become his PhD student, beginning one of the most extraordinary experiences of my professional life.

How did you go about making the book understandable?

The book starts on a beach where you, the reader, lie and stare at the night sky. Then you're off on a mind trip that will first take you through the visible Universe. You'll dive into the Sun to see why it shines. You'll cross the Milky Way and visit its central supermassive black hole before shooting straight to the boundary of what can be seen from Earth. Later, you'll find yourself as a mini-you, tinier than an atom, visiting the quantum world and witnessing a game of matter and light. To make it all understandable I used storytelling tricks, like in a thriller.

What aspects of physics do you cover?

I describe electromagnetism by showing why magnets stick to fridges, why we see each other, why we do not fall through the floor. Then I demonstrate the strong and weak nuclear forces by visiting the world of particles to see the forces that stabilise or destroy atomic nuclei, the very building blocks of the matter. And then come black holes, the Big Bang, quantum gravity and string theory, parallel universes, multiple realities and extra dimensions.

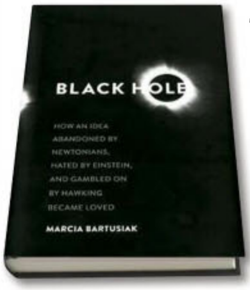
CHRISTOPHE GALFARD *is a science writer and public speaker who studied for his PhD at University of Cambridge*

BOOK OF THE MONTH

Black Hole

How an Idea Abandoned by Newtonians, Hated by Einstein and Gambled on by Hawking Became Loved

Marcia Bartusiak
Yale University Press
£14.99 ● HB



Today, we take it for granted that black holes are real, yet it wasn't always this way. This marvellous book tells the story of how the black hole went from a concept to a solid reality accepted by the astronomical community.

This is largely the story of gravity, and it opens with Newton, the man who showed that gravity was a force. British scientist John Mitchell speculated in 1783 what would happen according to Newtonian physics if a star's gravity were so powerful that it sucked in all light. The narrative then turns to Einstein, whose relativity showed us that gravity was not so much a force as a curvature of space and time.

The author goes on to recount the solving of Einstein's equations and what this implied: a singularity, the notion of which was originally abhorrent to scientists. We encounter super-dense objects – white dwarfs then neutron stars – with powerful gravities. And finally we see how astronomers went from this to the logical conclusion: that given even greater densities, there must come a point where the curvature of space is so great that even light is bent back in on itself. The story is told in an exciting manner, with dozens of interesting anecdotes; look out for the particularly amusing tale of Stephen Hawking's bet with Kip Thorne.

One quibble: the book is shorter than it would appear, as some 50 pages are taken up by a timeline, chapter notes and a bibliography. That aside, this is a thoroughly enjoyable and beautifully told trek through the annals of gravity research.

★★★★★

MARK GARLICK *is a former astronomer, currently a writer and illustrator*

Hubble's Legacy

Reflections by Those Who Dreamed It, Built It and Observed the Universe with It

Smithsonian Institution Scholarly Press
£16.47 ● PB

There are many books showcasing Hubble's glorious history, but what sets this one apart from most is that it is a collection of reflections, essays and insights by the people who dreamed of its existence and made it happen, and those who subsequently went on to use the now venerable space scope.

The first few essays are by senior NASA scientists involved with Hubble's conception and construction back in the 1960s, 70s and 80s, and it's wonderful to read about the mission's origins from people who were there at the beginning, as well as during the critical rescue mission in the 1990s. Former astronaut John Grunsfeld makes the servicing missions feel like much greater human endeavours after regaling accounts of seemingly everyday problems such as having to give a radiator "one last push" or struggling to remove a crucial bolt, all while on spacewalk.

Only two pieces are actually dedicated to Hubble's astronomical legacy, but that leaves more room for describing how the images are made and their role in bringing astronomy to the attention of the press and the public at large. There are some interesting thoughts on the artistic nature of the compositions, and similarities with the work of 19th-Century painters.

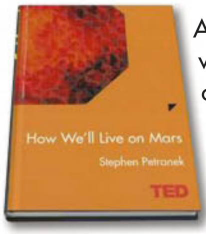
The final third of the book comprises a description of the preservation of Hubble's legacy in the Smithsonian and a report of the decision-making process around Hubble's final servicing mission in 2009. Apart from the inescapable acronyms and brief descriptions of magnitude limits, the book is largely non-technical, providing a fascinating and personal insight into the world's most famous telescope.

★★★★★

CHRIS NORTH *is a presenter on* The Sky at Night *and a Herschel outreach officer*

How We'll Live On Mars

Stephen Petranek
Simon & Schuster UK
£7.99 ● HB



A summary of the hows, whys and wherefores of colonising Mars, this book resembles a non-fiction companion to the novel (and movie) *The Martian*. It is actually a 'TED Book' spun out from the series of online talks, in this case one by technology forecaster Stephen Petranek. The text has the same characteristics as a TED – heaps of enthusiasm but little nuance.

Petranek is an extreme optimist, forecasting that the private sector – exemplified by SpaceX founder Elon Musk – will bypass an ossified NASA to deliver people to Mars within 20 years. But this thesis is already outdated: the June loss of a SpaceX Dragon spacecraft in a launch explosion demonstrates it is far from infallible, while the private Inspiration Mars initiative that Petranek highlights – to launch a manned capsule around Mars – evaporated once NASA failed to offer material support. And let's not mention Mars One's reality TV project.

Moreover, the author hardly addresses what it would feel like to live on Mars. Any travel brochure incorporating rover-snapped Mars portraits could be sued for false advertising: pictures are habitually brightened to enable geological analysis. As Petranek notes (without comment), colonists will live in perpetual gloom, receiving only 60 per cent of terrestrial sunlight. Not to mention ongoing radiation exposure, almost total airlessness, sometimes caustic regolith and noxious smells. Small wonder that in *The Martian* the hero spends the story trying to leave!

As a civilisation we've yet to settle on a convincing argument to go to Mars; we'll need really good reasons to stay. This book offers an introduction to the subject, but little more.

★★☆☆☆

SEAN BLAIR *is a journalist who writes for the European Space Agency*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

[redacted]

1 Geoptik CCD Adaptor for Canon Lenses

Price €99.17 • **Supplier** Geoptik
www.geoptik.com

This bright accessory allows you to attach the T2 thread of a CCD camera to the bayonet of a Canon EOS lens; the setup can then be mounted directly on a tripod or piggybacked on a scope. Maximum CCD diameter 110mm. CCD and lens not included.

2 Nebula Mug

Price £9.07 • **Supplier** Redbubble
www.redbubble.com/people/rapplatt

There's coffee in that nebula! Warm up after a long observing session with a hot drink in this stylish mug.

3 Night Sky MiniScope

Price £269 • **Supplier** iCandiApps
www.icandiapps.com

This tiny telescope is designed for use with an iPhone to take photographs at 50x magnification. It comes with its own tripod and an iPhone holder so you can start taking astrophotos straight away.

4 Orion Binocular Viewer for Telescopes

Price £199 • **Supplier** SCS Astro
01823 665510 • www.scsastro.co.uk

With this binocular viewer you can adapt your telescope to work with two eyepieces, increasing fine detail as well as creating a more comfortable viewing experience.

5 Philip's Moon Map

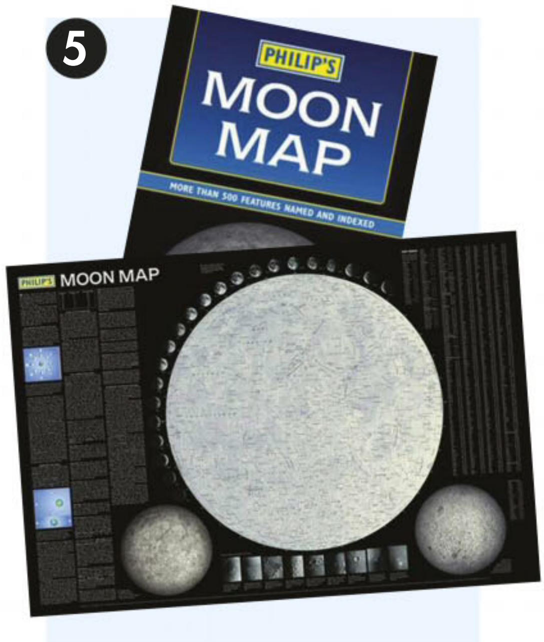
Price £6.99 • **Supplier** Waterstones
www.waterstones.com

With over 500 physical features, this folded map gives a clear and accurate representation of the near side of the Moon to help you find your way around our celestial companion.

6 Lacerta Solar Finder

Price £26.00 • **Supplier** 365 Astronomy
020 3384 5187 • www.365astronomy.com

This simple device helps you to align your telescope with the Sun. It is supplied with a Vixen-style base.



WHAT I REALLY WANT TO KNOW IS…
How can we read a galaxy's fingerprint?

Celestial sleuth **Trystyn Berg** is collecting forensic evidence to discover how galaxies have evolved

INTERVIEWED BY PAUL SUTHERLAND

One of the key questions in the quest to understand the nature of the Universe is how galaxies evolve. To help solve this riddle, I have been checking the chemical make-up of some of the most distant galaxies and comparing them to galaxies that lie much closer to home.

Most remote galaxies were created during the first three billion years of the Universe's existence, so the light from them that reaches us is more than 10 billion years old. The trouble is, the earliest galaxies are so distant that it is impossible to see individual stars within them – not even the most powerful telescopes can resolve them. So my colleagues and I had to find another way to check out their chemistry. This could tell us how these galaxies evolved, how many stars they contain and what type those stars are.

Going beyond

Our solution was to look for quasars that were more distant still. We looked for the intense points of light of quasars that have galaxies in the foreground, between them and us. As the light from the quasar passes through a foreground galaxy, some of it is absorbed by the galaxy's gas, leaving a kind of chemical fingerprint of the elements within that galaxy. This provides clues to its evolutionary history.

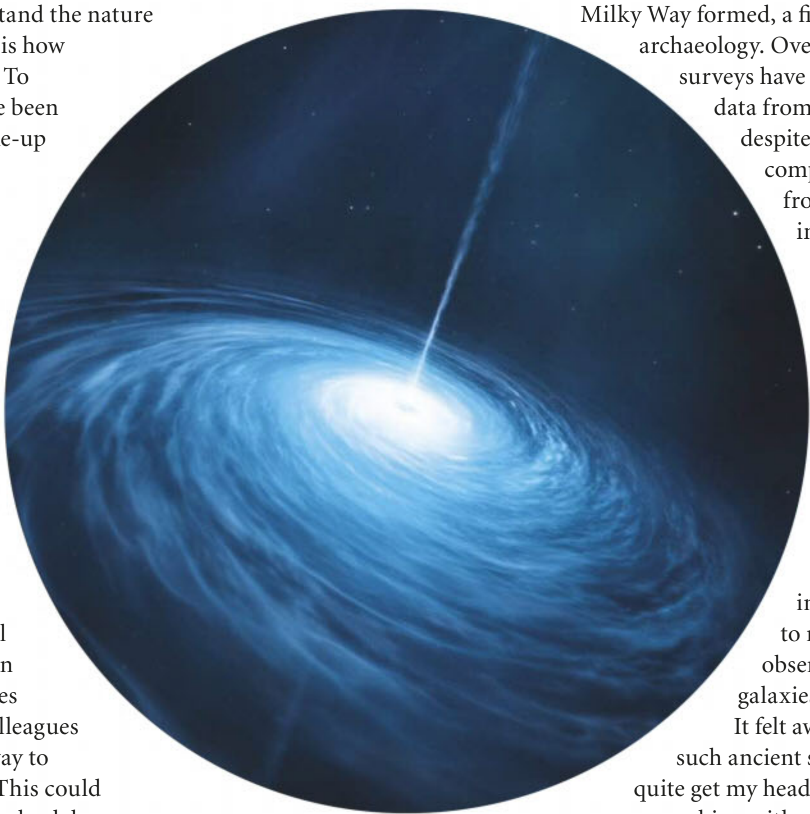
The technique itself is not new. It was pioneered about 30 years ago when astronomers wanted to find galaxies of similar type to the Milky Way in the early Universe. Because supernovae – the cataclysmic explosion that occur when massive stars reach the end of their lifetimes – release their elements into the gas of galaxies, the field naturally moved on to measuring their chemistry instead. Astronomers have also been using the chemistry of stars to understand how our own Milky Way formed, a field known as stellar archaeology. Over the past decade, sky surveys have collected a wealth of data from distant galaxies, but despite this, no one has compared the findings from them to what we see in nearby galaxies.

My team and I observed 30 distant galaxies using the Keck Observatory in Hawaii and added our findings about them to those from a previous sample of 340 galaxies. Our research allowed us to compare the chemistry in the faraway galaxies to nearly 2,000 stars observed in six nearby galaxies, including the Milky Way.

It felt awesome to be observing such ancient starlight. I still can't quite get my head around the fact that we were working with quasar light that had spent 10 billion years travelling towards us since being altered by a galaxy en route. It felt equally impressive to be able to measure amounts of elements in those distant galaxies to a similar accuracy, or maybe even better, than the chemistry of the nearby stars.

What we found was that many of the distant galaxies appear similar to smaller dwarf galaxies that orbit the Milky Way. However they are not identical, which is intriguing. Our results tell us what chemistry to go and look for to help learn how parts of the Milky Way system formed.

We will follow up on the research by using the Hubble Space Telescope to bring this technique closer to home. We are going to look at the gas outside galaxies that lie at a distance of up to 1.5 billion lightyears from us rather than 10 billion lightyears. We want to understand the properties of gas reservoirs in galaxies that will later form stars.



By looking at quasars shining through galaxies, the team were able to get an idea of the composition of the galaxies themselves

ESO/M. KORNMESSER

ABOUT TRYSTYN BERG
Trystyn Berg is looking for clues from the physics and astronomy department at the University of Victoria in British Columbia, Canada.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The Southern Hemisphere in September

With Glenn Dawes

WHEN TO USE THIS CHART

1 SEP AT 00:00 UT
15 SEP AT 23:00 UT
30 SEP AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

SEPTEMBER HIGHLIGHTS

Venus is worthwhile observing this month. Emerging from inferior conjunction in mid August, its apparent size shrinks in September as its phase grows. On the 1st it's 51.7 arcseconds in diameter and shows a thin phase akin to a one- or two-day-old Moon; by the 30th it is 33.6 arcseconds across with a phase close to a first quarter Moon. The planet is low in the eastern dawn sky on the 10th and 11th, in conjunction with the thin crescent Moon, with Mars below.

STARS AND CONSTELLATIONS

Capricornus is high in the evening sky. Nestled between Sagittarius and Aquarius, this constellation is almost invisible from light-polluted suburbia, but obvious from moonless country skies. Known since antiquity as the Sea Goat, its triangular group of 3rd- and 4th-magnitude stars resembles the roof of a house or an inverted smile. This part of the sky is rich in water-themed constellations, with Aquarius, Delphinus, Cetus, Piscis Austrinus and Pisces all nearby.

THE PLANETS

Mercury continues its best evening appearance for the year. Look for this inner world low in the west an hour after sunset; it is lost in the solar glare in the last week of the month. Saturn is the only other bright planet visible in the evening sky. It can be seen in the northwest, setting at around 23:00 EST midmonth. Venus rises at 04:30 EST. Mars, followed by Jupiter, slowly emerges from solar conjunction, rising up below Venus. All three are visible 30 minutes before sunrise by the 20th.

DEEP-SKY OBJECTS

Grus contains two interesting double stars, both easy to find. Start at mag. +2.1 Beta (β) Gruis – only 0.6° east is HR 8662 (RA 22h 46.7m, dec. –46° 57'). It has mag. +6.6 and. +9.9 components 10 arcseconds apart. Only 0.3° south of Beta Gruis is HR 8635. Its stars are mag. +6.0 and +11.1 separated by 7.5 arcseconds. You'll need at least 150x magnification to pry the faint companion from the glare of the primary.

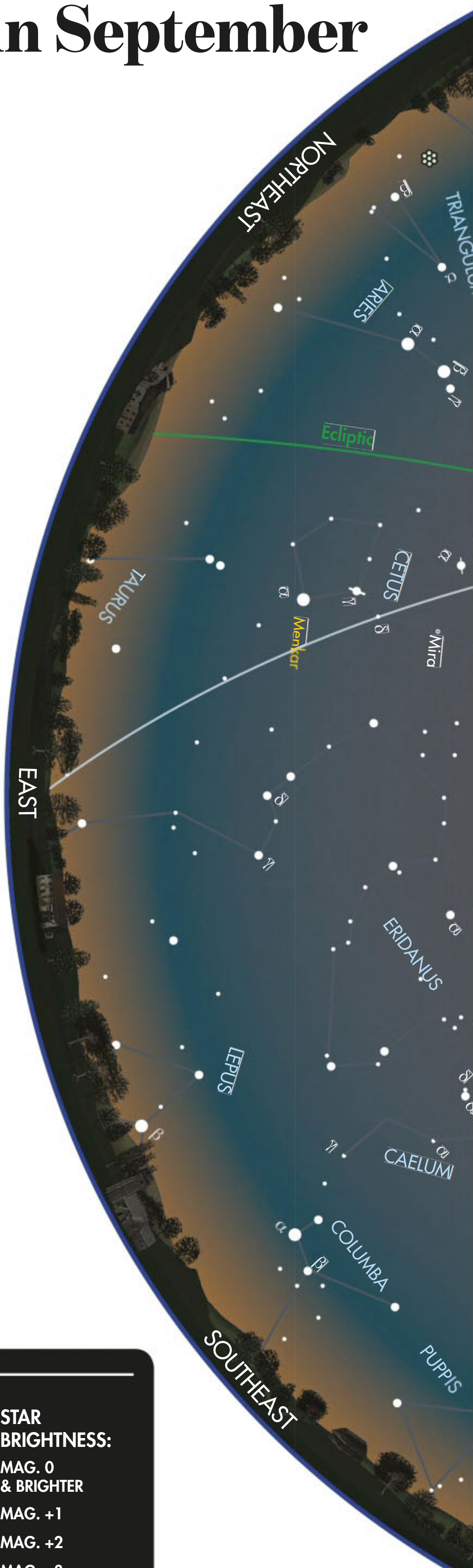
Move 7.5° north-northeast of Beta Gruis to reach the galaxy NGC 7410 (RA 22h 55.0m, dec. –39° 40'; pictured). This mag. +10.3 spiral is large (6x2 arcminutes) with a bright stellar nucleus, and an obvious central bar (3x1 arcminutes) with a mottled surface.

VERSCHATSE DANIEL/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT

CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER




NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
CYGNUS
Deneb
North America Nebula
NGC 7027
Cocoon Nebula
LACERTA
M39
ANDROMEDA
M31
M32
M110
Blue Snowball
Alpheratz
PISCES
PEGASUS
Great Square of Pegasus
Circlet
Enif
M15
EQUULEUS
DELPHINUS
Veil Nebula
Dumbbell Nebula
Summer Triangle
Northern Cross
Albireo
LYRA
Ring Nebula
VULPECULA
SAGITTA
Coathanger Cluster
Altair
AQUILA
Rasalhague
Water Jar
M2
Celestial Equator
1st
28th
25th
22nd
19th
AQUARIUS
Neptune
M30
CAPRICORNUS
PISCIS AUSTRINUS
Fomalhaut
Deneb Kaitos
NGC 253
SCULPTOR
NGC 300
NGC 7410
MICROSCOPIUM
GRUS
PHOENIX
FORNAX
HR 8662
HR 8635
INDUS
SERPENS CAUDA
M11
SCUTUM
M16
M17
M25
Pluto
M22
M23
M20
M8
OPHIUCHUS
M10
M12
SAGITTARIUS
Teapot
CORONA AUSTRALIS
M7
M6
M19
M62
Antares
M4
Saturn
SCORPIUS
ARA
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VOLANS
NGC 4833
MUSCA
CARINA
Southern Pleiades
Coal Sack
Jewel Box
CRUX
CENTAURUS
Eta Carina Nebula
Blue Planetary Nebula

UK Retailer Guide

Find the right one for you: buy your telescope from a specialist retailer

It is quite easy to become daunted by the vast array of equipment that is available to today's amateur astronomers. Different makes, different models, different sizes and optical arrangements – if you're new to the hobby, how do you make sense of all these details and find the telescope that will show you the Universe?

The answer lies in buying from a specialist retailer – somewhere that really knows what they're talking about. Like the retailers in this guide, they'll have the practical knowledge that will guide you towards the scope that won't end up gathering dust in a cupboard.

Today there are over 1,000 models of telescope to choose from – refractors and reflectors, Dobsonians and Newtonians, Schmidt- and Maksutov-Cassegrains. And just as important as the telescope is the mount it sits on; but do you go for equatorial or altazimuth, manual or Go-To? And what about accessories like eyepieces and finderscopes?

That's certainly a lot to consider before making a decision, but a specialist retailer will help you make that decision, taking important considerations like portability, construction and price into account.

So if you need friendly, face-to-face advice and excellent aftersales service, free from biased opinions, specialist telescope retailers are the place to go for a helping hand through the technical literature and tables of figures. They'll help you find a scope that combines quality and convenience at a price that's right.

TELESCOPE HOUSE

Founded in 1785, Telescope House has been responsible for supplying many well-known Astronomers with telescopes and equipment. The late Sir Patrick Moore bought the majority of his telescopes from the company, including his very first instrument. With a friendly showroom in Surrey, a number one ranked retail website and a service centre with fully qualified staff, the company offers equipment from manufacturers such as Meade, Revelation, Coronado, Bresser, Skywatcher, Orion USA, TeleVue, Vixen and Explore Scientific. Whether it's advice on your first telescope, to setting up advanced Astrophotography systems, the staff at Telescope House have a wealth of experience and instant access to the right stock to back it up.

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At Tring Astronomy Centre we know that choosing the right equipment can be a minefield, but we strongly believe that seeing telescopes in the flesh and talking to an expert in a relaxed environment can really help. That's why we have a coffee machine, a fully stocked bicuit barrel, and 45+ telescopes on display. As well as representing leading brands such as Celestron, Sky-Watcher, Baader Planetarium, Altair Astro, Vixen, Opticron, AstroTrac, iOptron, Lunt, Starlight Instruments, ZW Optical and many more we also offer a hire service so you can even try before you buy! So what are you waiting for? Visit or contact Tring Astronomy Centre and lets talk Astronomy!

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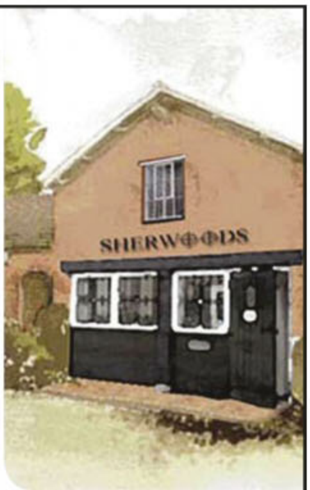

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